SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1899.

GENERAL PHYSICS.

771. *Flexibility of Marble Slabs.* **P. Gamba.** (N. Cimento, 9. pp. 117–130, 1899.)—The deformations of dry slabs of marble, under the action of certain loads, are determined (see Abstract 641, 1899). They are then soaked for forty-eight hours in various liquids, and their deformations under the same loads again determined. In general the soaking increases the deformation. Of the liquids tested, glycerine has the greatest effect; then follow oil, water, and paraffin dissolved in petroleum. The effect of petroleum alone is negligible. A. Gs.

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772. *Mechanical Properties of Copper.* **M. Rudeloff.** (Mitt. Königl. techn. Versuchsanstalten, Berlin, 16. pp. 171–219, 1898.) —Eleven plates or bars of copper containing from 97·3 to nearly 100 per cent. of copper (tin and zinc being the chief impurities) are submitted to an elaborate series of experiments on extension, with loads up to the breaking load at temperatures varying from −80° to 600° C. The numerical results are fully given in tables and curves. The general conclusions reached are:—

Mechanical treatment (hard drawing, rolling, or hammering) increases the strength, especially the stress at the limit of ductility, diminishing at the same time the extension of length at the fracture considerably, and producing, with the more impure samples, proportionality between extension and stress. The strength diminishes steadily as the temperature rises, but the diminution is considerably less up to 200° or 300° than at higher temperatures. The stretching with equal loads, within the limit of ductility, increases as the temperature rises; for some samples, however, this increase is only marked with higher loads. The extension of length at the fracture is increased by cooling to −20°; between

+20° and 300° it is nearly constant, whilst at higher temperatures it usually decreases with metal previously heated to redness and increases with the hammered or rolled material. The increased strength produced by mechanical treatment is retained almost unimpaired up to 200° to 300°, but at higher temperatures is gradually lost; at about 500° the hard and soft metals behave in nearly the same way. The proportionality between stress and extension produced by mechanical treatment disappears at from 200° to 300° C. The strength of the less pure specimens is on the whole increased more by mechanical treatment than that of the purer sorts, and the former retain their elasticity at higher temperatures. Hard rolling and hammering in the cold produce the same effects. T. E.

773. *Thermodynamic Equivalence in a Bimetallic Conductor.* **P. Straneo.** (Roma, R. Accad. Lincei, Atti, 8. pp. 196–202, 1899.)—Mathematical investigation of the conditions under a periodically reversed current through a bimetallic junction. A. D.

774. *Range of Molecular Forces.* **W. Mueller-Erzbach.** (Wied. Annalen. 67. 4. pp. 899–900, 1899.)—The author attempted to determine more accurately the thickness of the separating layer through which solid bodies are capable of exerting an attractive force upon the molecules of a gas. Rectangular glass plates 6 cm. long and 2 cm. wide were covered with a layer of sealing-wax or beeswax. They were then painted with a solution of gum in glycerine, about ten times in succession, each deposit being allowed to dry in until it was quite smooth. The strips were then put into test-tubes and introduced into vessels containing evaporating carbon bisulphide, but arranged in such a manner that the liquid bisulphide was always 1 or 2 degrees colder than the test-tubes. Some twelve or eighteen hours later the test-tubes contained some liquid CS_2, and drops of the same substance adhered to the covering layer—and that in spite of the higher temperature of the test-tubes. The thicker the layer of gum the feebler was the effect of the carbon bisulphide, until at last the test-tube, with its contents, showed no increase in weight. The thickness of the layers was determined by their weight. In the case of sealing-wax, covered with gum to a depth of 0·35 mm., no increase of weight was observed even after a fortnight's exposure. Under the same circumstances beeswax was protected by a layer only 0·14 mm. thick, whereas on sealing-wax the CS_2 penetrates a layer 0·16 mm. thick with ease. The slightest gap in the covering was at once indicated by a considerable increase of weight. With a degree of moisture of the air amounting to 72 per cent., thin gum layers over wax were so elastic that in many places solutions were formed under them, producing bulging of the layers. These solu-

tions partially evaporated in the open air, and were formed again on exposure to carbon bisulphide vapour. The covering remains, however, continuous, and does not tear unless the quantity of CS_2 absorbed is excessive.

Tissue paper soaked in gum has a protective action similar to that of pure gum, but much thinner coverings suffice. The same remark applies to collodion, but in using collodion care must be taken that it is in intimate contact with the glass. It is best mounted on a substratum of gum. Two films of collodion, with total thickness of 0·055 mm., together with a film of gum 0·056 mm. thick, formed an amply sufficient protection against solution by carbon bisulphide. It appears therefore that the transition to a second medium materially reduces the molecular motion. E. E. F.

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775. *Viscosity of Gases.* **P. Breitenbach.** (Wied. Annalen, 67. 4. pp. 803–827, 1899.)—The author uses the transpiration method, and an apparatus similar to that devised by E. Wiedemann. The gases examined include air, ethylene, carbonic acid, methyl chloride, and hydrogen. The following are the values of $\eta \times 10^7$ at 15° C.: Air 1809, ethylene 1011, CO_2 1464, methyl chloride 1057, hydrogen 893. The viscosity increases in proportion to a power of the absolute temperature whose index in the various gases lies between 0·6 and 1. It is therefore to be supposed that the sphere of influence of a molecule decreases as the temperature increases. For one and the same gas the index mentioned is not constant, but decreases with increasing temperature; even at low temperatures a decrease is observed. In mixtures of gases the viscosity does not change in proportion to the constituents, and Puluj's formula is only approximately correct. At higher temperatures the transpiration method gives results different from those of the method of oscillation, but the explanation based upon a supposed greater sliding of the gases along the wall of the tube at the higher temperatures does not appear to hold good. E. E. F.

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776. *Rate of Explosion in Gases.* **D. L. Chapman.** (Phil. Mag. 47. pp. 90–104, 1899.)—In this paper formulæ are given which express the maximum rates of explosion in gases and the maximum pressure in the explosive wave. The data used are mostly taken from the Bakerian Lecture of 1893 by Dixon, on the "Rates of Explosion in Gases." It has been established that the maximum velocity of explosion, in a mixture of definite composition and at a fixed temperature and pressure, has a definite value, independent of the diameter of the tube when that diameter exceeds a certain limit. Increase of temperature causes a fall in the velocity of explosion, whereas an increase of pressure has the reverse effect up to a certain limit, beyond which the

velocity remains constant. Dixon has also shown that an explosion is in its character essentially similar to a sound-wave.

The present paper is mathematical in character and the formulæ deduced, partly from experimental results, partly from assumptions not yet experimentally confirmed, are used to calculate the rates of explosion in various explosive mixtures. These calculated values are given in tables. J. J. S.

777. *Directive Action of one Crystal on another.* **J. H. Poynting** and **P. L. Gray.** (Roy. Soc. Proc. 64. pp. 121–122, 1898.)—Experiments were carried out in search of a directive action of one quartz crystal on another. Two quartz spheres were used, one 0·9 cm. in diameter, the other of 6·6 cm. diameter. The larger was rotated continuously near the smaller in a period of 115 seconds in one series, and in a period of 230 seconds in another series of observations. Any directive action should manifest itself as a periodic couple, producing forced oscillations in the smaller sphere. The results obtained were negative.

J. J. S.

778. *Velocity of Solidification.* **H. A. Wilson.** (Cambridge Phil. Soc. Proc. 10. pp. 25–35, 1898.)—A mathematical discussion of the relation between the velocity with which rays of solid grow in a super-cooled liquid when solidification is once started in it, and the amount of super-cooling. The rate at which solidification takes place depends upon the difference between the internal pressure in the solid and that in the liquid—a difference which in the case of water and ice at -1° C. amounts to 12 atmospheres. The investigation gives results parallel, for unconstrained material, to the lowering of the melting-point of ice, under pressure. If A is the force required to give unit velocity to one gramme of the liquid diffusing through itself, F the latent heat of fusion, a the thickness of a layer of molecules acted upon at the surface of separation (these being driven into the solid from the liquid), and $(\theta_0 - \theta)$ the super-cooling, then ω, the velocity of solidification is—

$$\omega = \frac{F}{Aa} \cdot \frac{\theta_0 - \theta}{\theta_0}$$

Since A increases rapidly as the temperature falls, ω attains a maximum, say at temperature θ_1. If the super-cooling be less than $\theta_0 - \theta_1$, the solidifying tip becomes warm, which retards the solidification; if it be greater the tip remains at θ_1, and the velocity of solidification is constant. Phenomena analogous to explosion occur when at very low temperatures the solidification is retarded by viscosity and then the supercooling is gradually diminished.

A.D.

779. *Limitations of the Present Solution of the Tidal Problem.* **J. F. Hayford.** (Science, 8. pp. 810–814, 1898.)—The theory of the tides furnishes the periods, not the actual times of the occurrences of the tides, *i.e.*, the epochs of the components, not their range. The author explains the nature of the problems by first assuming that the earth is a rigid nucleus, covered by a uniform depth of water, and that the moon always presents the same face to it. Coming nearer to the actual conditions, he finds that if the earth were covered with water up to the top of Mount Everest—that is, to a maximum depth of ten miles—the mathematical solution, so far possible, would be almost intractable. The apparent rate of progress of the moon over the earth's surface is seventeen miles per minute; the tidal wave would be able to follow the moon if the ocean had a depth of thirteen miles. For depths varying between ten and five miles, the rate of progress of the tidal wave would vary between ten and one mile. The moon would tend to break down the old wave, and to build up a new one in advance of it. The actual conditions add to these difficulties a maximum sea depth of about five miles and reflections from exceedingly irregular shores. The real tidal wave moves northward in the Atlantic and part of the Pacific, and has an eastward tendency in at least two large areas, north of Europe and west of South America. In the Atlantic the semidiurnal components are large as compared to the diurnal components; in parts of the Pacific they are small, so that the two tides of one day are of very different heights, and so that only one tide per day may result. At Batavia, *e.g.*, the component which has one high water per sidereal day is six times as large as the component having two high waters per lunar day. The conflicts with shores and bottom leave only the periods unaffected, the amplitudes are greatly changed. The effects of boundaries, bottom and sides, can best be studied in bays receiving tributaries of known depths, such as Chesapeake Bay, where complete data are obtained at Old Point Comfort, Baltimore, and Washington, and where observations are taken at forty-nine points on the bay, twenty-one along the Potomac, and sixty-one along other tributaries of the bay. The author suggests a graphic, rather than an analytic, study of this comparatively unworked field of the problem as most promising for extending our knowledge of the tides. H. B.

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780. *Gravity Determinations.* **K. R. Koch.** (Zeitschr Instrumentenk. 18. pp. 293–300, 1898.)—The author is going to carry out some determinations of the relative values of gravity in the kingdom of Wurtemberg. 1. He describes a support for a pendulum, devised by himself, which is practically free from sympathetic vibrations. 2. He gives details of comparisons between a standard clock and a chronometer with an arrangement for an electrical contact; also between a standard clock,

and a clock, without compensation, beating half-seconds. The tests prove the auxiliary instruments to be unsatisfactory. 3. He describes the apparatus he intends to use. In the central station there will be a Hipp's clock, provided with a Riefler's pendulum. This pendulum has an electrical contact, and will be put in communication with the field-station by means of relays, experiments proving that their time-lag is practically constant. Thus the Riefler's pendulum can be compared with the movable one. Riefler's pendulum itself will be compared systematically with a standard clock. 4. Some experiments are performed which prove that if a pendulum has been lying in its case for some time its time of vibration increases with use, probably due to a gradual stretching by its own weight. Further experiments are in progress. A. Gs.

781. *Periodicity and Velocity of Earthquakes.* **A. Cancani.** (Roma, R. Accad. Lincei, Atti, 8. pp. 76–79, 1899.)—The paper has reference to the earthquakes which have occurred for centuries in the neighbourhood of the Marches and Roumania. The periodicity of the most violent disturbances is 100±14 years. There are additional earthquakes with a periodicity of 23±10 years. The velocity of the shock which occurred on the 21st of September, 1897, was 0·86 kilometre per second to Florence, a distance of 165 kilometres from the epicentre; it was 1·46 per second to Rome at a distance of 240; and 3·62 per second to Utrecht a distance of 1,050 from the epicentre. A. Gs.

782. *Temperatures on Mountain-tops.* **J. Hann.** (Wien Akad. Sitzber. 107. pp. 537–568, 1898.)—The author compares the temperature curves registered at the observatory on the summit of the Sonnblick (3106 m.), and at the "Hannwarte" on the Obir (2140 m.). At the latter, the mean daily amplitudes are small. They amount to 0·9° in winter, 2·5° in spring, 3·8° in summer, and 1·6° in autumn. In November and December a very peculiar phenomenon is observed. There is the usual maximum at 2 p.m., but a secondary maximum is observed at 4 a.m., which at other seasons records the minimum. This maximum is due to the strong descending currents of air which prevail at that season, and which bring warmer currents to the mountain-tops. This phenomenon is not observed on the Sonnblick, on account of its greater height. E. E. F.

LIGHT.

783. *Reflection and Refraction of Light.* **Lord Kelvin.** (Phil. Mag. 47. pp. 179–190, 1899.)—Lord Kelvin discusses the subject for waves of compression-rarefaction as well as distortion at a plane interface between two isotropic elastic media. The general treatment is on the same foundation as his paper in Phil. Mag., 1888, pp. 414–425, but somewhat simplified. Assuming the velocity of the compression wave to be very small compared with that of the distortion wave, he obtains an expression for the ratio of the amplitudes of the incident and reflected distortional waves, which yields Fresnel's sine law if the densities of the two media are equal, and Fresnel's tangent law if the rigidities are equal. He also discusses shortly the case of the imaginary wave in total reflection. S. H. B.

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784. *Extension of Maxwell's Theory.* **E. Edser.** (Roy. Soc. Proc. 63. pp. 374–389, 1898.)—A dielectric, like an electrolyte, is assumed to consist of molecules, each comprising, in the simplest case, two oppositely charged atoms at a definite distance apart. In a homogeneous medium, when not subjected to electric strain, these molecules will be arranged in such a manner that any element of volume will possess no resultant electric moment. If a definite potential difference be maintained between any two parallel planes in the medium, the positively charged atoms will move to points of lower, and the negatively charged atoms to points of higher, potential. Thus two kinds of molecular strain are produced: firstly, a molecular rotation; and secondly, a separation in the molecule of the constituent atoms. Some observations are added on the resultant field acting on a polarised molecule in a dielectric subjected to strains such as those considered. Subsidiary equations for the atomic vibrations (rotational separational) are given, and the refractive index is finally determined in the form

$$u^2 = \mu_\infty^2 + \frac{c'\lambda_1^2}{\lambda^2 - \lambda_1^2} + \frac{c''\lambda_2^2}{\lambda^2 - \lambda_2^2},$$

which is a general form of Ketteler's dispersion formula.

Double refraction, in the case of a uniaxal crystal, is explained on the assumption that the molecules are arranged with their axes parallel to a certain direction. Electrical disturbances perpendicular to this direction will produce a molecular rotation, whilst those parallel to this direction will produce an inter-atomic separation. The doubly refracting nature of a dielectric when subjected to electric strain is thus explained. For infinitely quick vibrations the refractive index of the above medium will be equal to unity—a result possibly explaining the action of material bodies on Röntgen radiations. From the equations obtained it is further shown that the coefficient of absorption of a feebly absorbing substance or mixture is proportional to the number of absorbing molecules per unit volume. E. E. F.

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785. *Colour of Iodine Vapour.* **J. Dewar.** (Cambridge Phil. Soc. Proc. 10. pp. 44–47, 1898.)—Pure iodine in the solid state is usually represented as being perfectly opaque to light, but this is not the character of the iodine distilled and condensed on a surface of glass at temperatures between −182° and −183° C. in vacuum test-tubes or bulbs by the use of liquid air. Under such conditions it is easy to get transparent films of iodine of varying grades of thickness showing brilliantly the colours of thin plates by reflection; and to keep them permanently as long as the low temperature is maintained. The first addition of liquid air to the vacuum bulb or test-tube containing excess of solid iodine causes instant precipitation of an opaque film, but this can be avoided by cooling the crystals of iodine which have been sublimed on to the lower part of the outer test-tube or bulb by a preliminary cooling with solid carbonic acid. The iodine is thus deposited from an atmosphere of great tenuity. Now J. J. Thomson has shown that the effect of the pressure of an inert gas must be to raise the vapour pressure above that given in a vacuum. Taking his formula as being applicable to iodine, the difference between the two conditions of pressure should amount to $\frac{1}{440}$ of the whole. The question remains as to whether this amount is sufficient to explain the difference of colour, or whether it is necessary to bring in other factors, such as the solution of solids in gas under compression, or dissociation. So much is certain, that one atmosphere of pressure is sufficient to produce a sensible difference of colour in iodine vapour diffused in air as compared with a vacuum. E. E. F.

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786. *Objectives of Small Aperture.* **H. Harting.** (Zeitschr. Instrumentenk. 18. pp. 331–335, 1898.)—A collection of formulæ for three radii of a cemented bipartite objective, calculated from the glass, the working distance and the length of tube; applicable to water immersion as well as to several dry systems. The formulæ are developed in full in Sitzber. d. K. Acad. d. Wiss., Wien, Math.-naturw. Kl., 107, IIa, p. 624. The objects in view are, with two lenses cemented together (of glass selected in accordance with the results of calculation), to provide a given focal length or else a given working distance, to achromatise for two parts of the spectrum, to eliminate spherical aberration for one colour, and to do the same for slightly non-axial rays. A. D.

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787. *Compound Objectives.* **H. Harting.** (Zeitschr. Instrumentenk. 18. pp. 357-380, 1898.)—With the older kinds of crown and flint glass two object lenses could not be so cemented together that besides achromatism and correction of spherical aberration the sine rule should be rigidly observed. In all pairs of lenses which could be combined from the older crown and flint glasses, the dispersion of the crown was too high and that of the flint too low in comparison with the refractive index. Hence the objectives so made up always showed spherical aberration outside the axis after it was eliminated within the axis. The new glasses produced at Jena provide a nearly perfect solution of the problems referred to in two ways. The first is a combination of a borosilicate crown of low refractive index (say 1·50) and comparatively small dispersion with a lead-silicate flint of relatively high refractivity (say 1·64). The second is a combination of a barium-silicate crown of high refractivity (1·58) with a flint whose refractivity need only be very slightly higher (0·01). This latter combination also offers the advantage of smaller external curvatures, and consequently greater apertures for the same spherical aberration. The problem of a perfect objective is thus within measurable distance of a final solution. E. E. F.

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788. *Recent Views on Colour.* **A. H. Abbott.** (Canad. Instit. Proc., Parts 1, 4, and 5. pp. 107-108, 1898.)—A summary of recent views as to the nature of colour, looked at from the psychological point of view. J. B. H.

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789. *Photometric Standards.* **F. Laporte.** (Elettricità, Milan, 17. pp. 755-759, and pp. 775-778, 1898).—Incandescent lamps standardised at the Physical Technical Institute, Charlottenburg, were examined at the Central Laboratory of Electricity, Paris. On the assumption that one Hefner unit is equal to 1·02 decimal candle or 0·051 Violle platinum unit, the comparative data were:—

Volts.	Amperes.	P. T. Institute.	Central Laboratory.	
		Hefners (obs.)	Decimal candles.	Hefners (calc.)
108·5	0·338	10	8·7	8·5
111·5	0·489	16	14·2	13·9

This led to a full comparative series of experiments. It was found incidentally that unless the ventilation of the photometer room is very good, the Carcel lamp becomes sluggish and the fall off in lighting power is greater than the fall off in consumption of oil: so that in a room of 82·6 cub. metres, without ventilation, in two hours the consumption falls by 4 and the lighting power by 12 per cent. Under proper conditions the Carcel was found equal to the Bengel burner, consuming 105 litres of Paris gas per hour. In the Hefner lamp (Liebenthal) the variations due to height of flame are on the average: 38 mm., 0·941; 39 mm. 0·971; 40 mm. 1·000; 41 mm., 1·027; 42 mm., 1·054; and if x be the number of litres of water and vapour in a cubic metre of the air, the lighting power is $1·049\,(1-0·0055x)$, so that the standard power corresponds to a humidity of about 8·8 litres water-vapour per cubic metre. Carbonic acid, y lit. per cub. m., gives lighting power $(1·012-0·0072y)$. Defect of oxygen in the air lowers the power about 2 per cent. per litre of defect per cubic metre. The following table shows the results of the experiments:—

	Decimal candle.	Carcel lamp.	Hefner lamp.	German standard paraffin candle.
Decimal candle ...	1·000	0·104	1·13	0·955
Carcel lamp.........	9·600	1·000	10·90	9·200
Hefner lamp	0·885	0·092	1·00	0·815
German standard paraffin candle...	1·050	0·109	1·23	1·000

These results differ considerably from the datum 1 Hefner = 0·120 to 0·126 Carcel, obtained with the earlier but more variable models of the Hefner lamp. A. D.

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790. *Multiple Images in the Normal Eye.* **S. Bidwell.** (Roy. Soc. Proc. 64. pp. 241–245, 1899.)—A description is given of experiments on vision in which a luminous object, *e.g.*, the bright filament of an incandescent lamp is looked at through a lens, concave or convex, say of about 15 cm. focal length from a distance of a few feet. The roughly oval patch of luminosity formed upon the retina appeared to be made up of a crowd of separate images of the filament, some being brighter than others. The number of these images increased as the distance of the observer from the lamp increased, or when the lens was placed farther away from the eye. By sufficiently increasing the distance between the source of light and the eye as many as twenty-five images of the source (or thereabouts) might be made to appear in a row. The number of images thus seen varies with the dilatation of the pupil. There are indications that the original images may

be resolved into still simpler elements, giving 400 or 500 as the total number of elements produced by one source. These latter observations seem to indicate some fairly regular anatomical structure in or near the crystalline lens, and composed of cells measuring about 0·01 mm. in length or breadth. Possibly the cause may be found in the endothelium on the anterior surface of the lens, the cells of which are about 0·02 mm. in diameter. There is more difficulty in accounting for the formation of the images numbering twenty-five in a row, as no structure sufficiently coarse-grained to account for them (a network with meshes 0·2 mm. in length would be required) occurs in the eye. The author considers the effect may be a composite or differential one. J. J. S.

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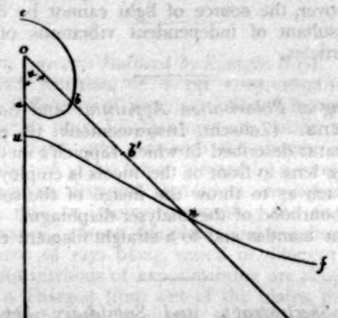
791. *Graphical Method of Determining Illumination.* **L. Hoest.** (Bull. Ass. Ing. El. Liège, 9. pp. 464–470, 1898.)—When it is required to find the illumination at every point of a horizontal plane due to a luminous source whose intensity in every direction is known, the following graphical method affords a rapid means of solution. The well-known formula $Ih^2/\cos^3 \alpha$ gives the illumination at a point R of a horizontal surface due to a source whose height above it is h, and whose intensity in the direction of the point is I, α denoting the angle made with the vertical by the line joining R to the source. By putting $Ih^2/\cos^3 \alpha =$ constant, and tracing the corresponding curve $u\,n\,f$ (see fig.), whose radius vector $On = I$ gives the luminous intensity of an *ideal* source which produces uniform illumination over a horizontal plane, we obtain a standard curve which is extremely useful for the rapid determination of the illumination due to any other source, such as the one whose luminous characteristic is represented by $a\,b\,c$ in the figure. For if



$V = Oa/h^2$ stand for the illumination at P due to the given source, and if we lay off Ob' so that $\frac{Ob'}{On} = \frac{Oa}{Ou}$, then we have

$$\text{illumination at } R = V\frac{Ob}{Ob'} = V\frac{Ob}{On}\cdot\frac{On}{Ob'} = V\frac{Ou}{Oa}\cdot\frac{Ob}{On} = \frac{Ob}{On}K,$$

where $K = V\frac{Ou}{Oa}$ is a constant. Hence the horizontal illumination at any point is at once determined by multiplying K by the ratio Ob/On corresponding to the point considered. A. H.

792. *Radiation in a Magnetic Field.* **D. Macaluso** and **O. M. Corbino.** (Roma, R. Accad. Lincei, Atti, 8. pp. 38–41, 1899.)—At each side of an absorption line the light not only has its plane of polarisation rotated, but the plane-polarised light becomes elliptically polarised, this latter effect rapidly dying out as we pass away from the centre. A. D.

793. *Zeeman Phenomenon.* **O. M. Corbino.** (Roma, R. Accad. Lincei, Atti, 8. pp. 171–175, 1899.)—Comes with Righi to the conclusion (see 1899, Abstracts, No. 423) that experiments with shifting beat-fringes are impossible with the light from Zeeman's tubes; for though, analytically, Righi's difficulties could be got over, the source of light cannot be made unique but is the resultant of independent vibrations of an infinite number of particles. A. D.

794. *Lighting of Polarisation Apparatus and Saccharimeter.* **F. F. Martens.** (Zeitschr. Instrumentenk. 18. pp. 335–337, 1898.)—Apparatus described in which Lippich's method of using an illuminating lens in front of the nicols is employed, the focal length being such as to throw the image of the source of light into the neighbourhood of the analyser diaphragm. Adaptations to incandescent mantles and to a straight-filament electric glow-lamp. A. D.

795. *Quartz-Spectrographs and Subsidiary Apparatus.* **C. Leiss.** (Zeitschr. Instrumentenk. 18. pp. 325–331, 1898.)—Descriptions of apparatus made by Fuess, of Steglitz, near Berlin: Schumann's quartz spectrograph, large and small model, his simplified quartz condenser, his sparking apparatus, and his universal sparking apparatus. Photo process reproductions of the spectrographic results obtained with commercial glass plates, up to the aluminium line 1852 in the ultra-violet are given. A. D.

796. *Scale of Kirchhoff's Solar Spectrum.* **J. Hartmann.** (Berlin Akad. Sitzber. 46. pp. 742–756, 1898.)—The reduction of Kirchhoff's measurements to a scale of wave-lengths in absolute measure is difficult on account of the fact that his apparatus was differently adjusted for the different parts of the spectrum measured. Between D and F the scale drawn by Kirchhoff is too great, while in the outer portions it is too small. The difference is so great that between B and D the spectrum would have to be half as large again to correspond to the central scale. The author determines formulæ for the reduction of Kirchhoff's arbitrary scale to absolute wave-lengths, and tests the values given by the formulæ by comparing them with Rowland's photographic map of the solar spectrum. He finds that Kirchhoff's spectrum has to be divided into five portions, and different formulæ apply to the various portions. The first portion extends from A to D, the second from D to E, the third to 497 mm., the fourth to 471 mm., and the fifth is the rest of the visible spectrum. The reducing formula for the fourth portion, which deviates the most, is:—

$$\lambda = 891{\cdot}04 \text{ mm.} - \frac{6{\cdot}290971}{6904{\cdot}6 - K}$$

where K is Kirchhoff's scale-reading.

Apart from the faults of scale, the observations of Kirchhoff are of the most admirable precision. The probable error of a wave-length determination from the new formulæ is only about half an Ångström unit. E. E. F.

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797. *Electric Currents Induced by Röntgen Rays.* **A. Winkelmann.** (Wied. Annalen, 66. 1. pp. 1–28, 1898.)—This paper deals with the difference of potential induced between two plates of different metals when Röntgen rays are caused to traverse the space between them, and also with the electric current which passes when the two plates are connected by a wire.

Plates of copper, zinc and aluminium are experimented with, the Röntgen rays successively traversing the two plates normally, the distance between the plates and the distances of both from the source of rays being varied in different experiments. Several different methods of experimenting are adopted. In one a condenser is charged from one of the plates, the other being connected to earth, and the charge on the condenser after one, two, or several minutes' action is measured by a ballistic galvanometer. In a second, the current to earth from one plate is measured by a galvanometer, the other plate being also connected to earth. The difference of potential between the plates is measured by an electrometer. In a third method the electrometer is used also as the current measurer with the aid of a known resistance.

The results are all in accordance with the theory that the air between the plates is *ionised*, and that almost immediately after the rays start a constant electromotive force exists between the plates analogous to the contact-difference of potential. The results of the time experiments with the condenser, when calculated theoretically on this assumption two experiments being included to give the constants, are in close agreement with the experimental results.

The currents measured are of the order of $6{\cdot}7 \times 10^{-9}$ amp. The resistance of the air between the metal plates is calculated from the current and the difference of potential, and from it the lower limit to the number of dissociated molecules per c.c. of air is found to be $4{\cdot}6 \times 10^{-13}$. J. B. H.

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798. *Gases Subjected to Röntgen Radiation.* **J. Zeleny.** (Cambridge Phil. Soc. Proc. 10. pp. 14–25, 1898.)—The passage of electricity through a gas under the influence of Röntgen rays is accompanied by movements of the gas itself, which are of considerable magnitude and can be rendered visible by NH_4Cl fumes, streams of which crossing the direction of conduction are deflected or bodily carried each to its neighbouring plate. For a given intensity of the rays the rate of the motion is dependent upon the potential gradient between the plates. In the absence of the Röntgen rays the motion of the fumes is not affected by the electric field. Streams of carbonic acid gas show similar results. The gas is dragged by the moving ions; equally in both directions if there be no free charge; more in one direction than the other if there be a free charge, *i.e.*, if the ions of one kind be more numerous. With limited plates the excess of pressure at their surfaces is relieved sideways, so that convection currents are set up, ultimately assuming a steady state. Measuring potentials extremely near to the plates, it appears that in the first tenth of a millimetre the fall of potential is about equal to what it is in the next three-tenths. The electric force acting upon the electrodes is increased by exposing the gas to Röntgen rays.

A. D.

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799. *Stereoscopic Radiography.* **V. Chabaud.** (Séances Soc. Franç. Phys. 3. pp. 154–164, 1898.)—The author describes an apparatus by which a foreign intrusion can be found in the human body, its place determined, and its distance from a given point of the skeleton found. It enables the operator in a few minutes to take two radiographs, to develop them, and examine them in a special stereoscopic apparatus and to draw conclusions therefrom. This result is achieved by the use of a vacuum tube which gives very rapid records, and a stand which enables the operator to take two radiographs of the same object from two different but precisely defined foci. E. E. F.

HEAT.

800. *Coefficient of Expansion of Air.* **W. Hoffmann.** (Wied. Annalen, 66. 2. pp. 224–236, 1898.)—The first part of this paper contains an experimental determination of the pressure-temperature coefficient of air at constant volume, and the second part an experimental comparison of this coefficient with the volume-temperature coefficient at constant pressure.

In the first investigation a constant volume air thermometer is used, in which the influence of variations in the atmospheric pressure is eliminated by having the pressure column of mercury in a long tube exhausted and closed at the top, thus forming a barometer. The experiment is performed in the usual way between two fixed points of temperature. The results of three experiments are :—

$$\begin{aligned} 1.\quad a_p &= 0{\cdot}00367064 \\ 2.\quad a_p &= 0{\cdot}00366897 \\ 3.\quad a_p &= 0{\cdot}00366911 \\ \text{Mean}\quad a_p &= 9{\cdot}00366957 \end{aligned}$$

The comparison of the two coefficients is carried out by means of a modified constant volume air thermometer, which can be used also as a constant pressure thermometer. An extra bulb is blown on the vertical capillary tube above the mercury index tube. This bulb is also provided with an index at its upper end. The volume of this bulb is made such that if the apparatus be used as a constant pressure air thermometer, this subsidiary bulb being kept in ice, the two fixed points of the thermometer are the two index marks, the zero being that at the top of the bulb and 100° being the one in the mercury tube. This condition is only approximately fulfilled, corrections being made from accurate measurements of the pressures.

The results of some preliminary experiments give the mean value—

$$a_v - a_p = 0{\cdot}00000123.$$

J. B. H.

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801. *Pressure and Temperature of Fusion.* **Demerliac.** (Journ. de Physique, 7. pp. 591–598, 1898.)—In this paper the results are given of experiments instituted to determine the connection between the pressure and the temperature of fusion (see Phys. Soc. Abstracts, 1897, No. 183). The substances experimented on are benzine, ethylene bromide, paratoluidine, and naphtylamine.

The variation of the temperature of fusion corresponding to an increase of pressure of 1 atmosphere is obtained by finding the variations for increments of pressure of 5, 10, 15, and 20 atmospheres and substituting in the equation—

$$t - t_0 = ap - bp^2$$

thus obtaining values for a and b. The increments of temperature for 1 atmosphere, thus obtained, agree to 0·4 per cent. with those calculated by Clapeyron's formula.

The apparatus and method having thus been proved to give trustworthy results the experiments are continued to high pressures. In every case the curve of variation of temperature is found to agree very closely with an arc of a hyperbola.

The equation in the case of benzine is—

$$0{\cdot}00002109\,p^2 + 0{\cdot}003544\,pt - 0{\cdot}10598\,t^2 - 0{\cdot}030143\,p + t = 0,$$

p being measured in atmospheres and t being the variation of temperature in degrees Cent. This equation gives a maximum increase of temperature of 4·528° at $p = 334{\cdot}2$ atmospheres, which agrees perfectly with the point where the curve becomes to all appearance parallel to the axis of pressure. The equation gives a subsequent fall in the curve which experiments have, however, failed to discover.

If we assume that the curve is part of a hyperbola whose asymptote is parallel to the axis of pressure, the agreement between the experimental curve and this hyperbola is not so close as it is with the first one.

Similar experiments on water give 0·00757° for 1 atmosphere as the lowering of the freezing-point. The curve in this case is only very slight, the concave side being towards the axis of pressure. The curvature is so slight that the equation to the curve cannot be obtained. The value of Joule's equivalent calculated from these experiments on water is 42·44 or 42·65, according as the latent heat is taken as 79·63 or 79·25.

J. B. H.

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802. *Variation of Specific Heat with Temperature.* **L. Sohncke.** (Wied. Annalen, 66. 1. pp. 111–115, 1898.)—The author compares the temperature coefficients of the specific heats of solids, liquids, and gases. For solids he finds they vary from 0·001 to 0·002, for liquids from 0·001 to 0·003, and for gases from 0·001 to 0·0025: From this close agreement he concludes that for all bodies in general, when the substance is not at a temperature near that at which it changes state, the alteration of the specific heat with temperature is determined principally by the increase of the internal energy of the molecules. From this it follows that the specific heat of bodies whose molecules contain only one atom, ought not to increase with temperature. For mercury and cadmium in the liquid and solid states respectively, a decrease of specific heat has been found. The author accounts

for this decrease by the diminution of the mutual action of the molecules on one another, owing to their increasing distances apart, due to the rise of temperature.

There are thus three physical properties of mercury which go to prove that its molecule contains only one atom. 1. The value of $\gamma = 1{\cdot}67$. 2. The fact that its specific heat volume constant in the gaseous state is one-half the specific heat in the solid state. 3. The fact that the specific heat in liquid state decreases with temperature. J. B. H.

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803. *Thermal Conductivity of Solids.* **F. A. Schulze.** (Wied. Annalen, 66. 2. pp. 207–223, 1898.)—In this paper a new method of determining the thermal conductivity of solids is described. A rod of the metal or other solid to be experimented on is allowed to assume a uniform temperature, preferably that of its surroundings. One end of the rod is suddenly brought to and kept at another constant temperature, either higher or lower than the temperature of the rod. This is done by a jet of water at the constant temperature being allowed to play on the end, and the end only. A thermoelectric junction gives the temperature at a point of the rod which is a few centimetres distant from the end in question. The times are noted by an electric chronograph, at which the galvanometer connected with this junction shows deflections of from 1 to 8 scale divisions. From the data thus obtained the conductivity is calculated. The mathematical analysis is given in the paper and the assumptions made are discussed and justified.

The results of eighteen different experiments on a copper bar are given, and the mean value for the conductivity obtained is 0·6108, the maximum variation being 4 per cent. and the probable error less than 1 per cent. J. B. H.

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804. *Thermal Conductivity of Glasses.* **A. Winkelmann.** (Wied. Annalen, 67. 4. pp. 794–802, 1899.)—The author replies to Focke's criticism of Paalhorn's work on the above subject, and maintains that the sources of error in the latter are not serious. He points out that lead glasses are very difficult to obtain of definite composition, since they take up alumina from the walls of the crucibles. One can never be certain that two glasses have the same composition unless they come from the same melting. Whatever differences there are between Focke's and Paalhorn's conductivities are probably due to a temperature change of the conductivity whose coefficient has not yet been determined.

E. E. F.

805. *Aspiration-Thermometer.* **P. Fuchs.** (Zeitschr. Instrumentenk. 18. pp. 337–338, 1898.)—A substitute for Daniell's Hygrometer, consisting of a thermometer with a tubular passage through its quicksilver reservoir, which tubular passage is used for evaporating ether by aid of an aspirator, and thus cooling the mercury itself, more or less rapidly according to the aspiration. The instrument both indicates the temperatures and shows the dew-point, and is graduated down to about – 10° C. A. D.

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806. *Pressure of Water Vapour below Zero.* **M. Thiesen.** (Wied. Annalen, 67. 3. pp. 690–695, 1899.)—The author calculates the pressure of saturated water vapour over water and over ice respectively at temperatures down to – 80° C., on the basis of the equation of Clapeyron and Clausius. The following are some of the values:—

Temperature.	Pressure over ice mm. Hg.	Pressure over water mm. Hg.
0°	4·581	4·581
– 10°	1·946	2·145
– 20°	0·772	0·939
– 40°	0·096	
– 60°	0·008	
– 80°	0·0004	

E. E. F.

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807. *Gases which obey Joule's Law.* **F. Carré.** (Journ. de Physique, 7. pp. 718–719, 1898.)—A gas which follows the laws of Boyle and of Gay-Lussac, follows also Joule's law; such a gas is called a perfect gas. The converse does not always hold true. A gas whose laws of compressibility and dilatation may be represented by the equation

$$p\,(v-b)=\mathrm{RT}$$

would obey neither the law of Boyle nor the law of Gay-Lussac, but yet would obey Joule's law. The formulæ of Van der Waals, of Clausius, of Sarrau—those of the general type $(p+a)\,(v-b)=\mathrm{RT}$—are only applicable to gases which follow Joule's law. If, referring to Amagat's experiments, a gas is considered whose characteristic function takes the form

$$p\,(v-b)=\mathrm{RT}$$

it is certain that the gas follows Joule's law although it may always depart from Boyle's law. J. J. S.

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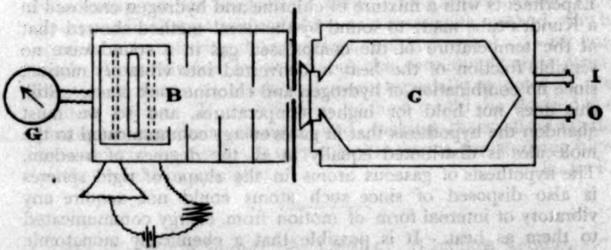
808. *Radiating Power of Platinum Black and Lampblack.* **F. Kurlbaum.** (Wied. Annalen, 67. 4. pp. 846–858, 1899.)—

All measurements of radiation depend upon the absorptive qualities of the thin layer which is deposited upon the sensitive surface of the bolometer or thermocouple. Most observers measure the maximum emission of the layer, in order to study its absorptive power. It is generally assumed that the emission increases at first with the thickness of the layer, and then decreases again when a certain thickness is reached, on account of the low conductivity of the black substance. The author compares the black surfaces with the ideal black body devised by Kirchhoff, and shows that very thin layers, which optically fulfil the requirements of absolute blackness within a few per cent., do not possess half the thermal absorption possessed by the ideal body. The method employed consists in determining the emission of layers of various thicknesses with the emission of the ideal body at the same temperature, say 100°. The measure of the thickness of the layer is its mass per square decimetre. The arrangement of the radiating body and the bolometer is shown in the diagram.



C is a brass cylinder blackened inside and closed at the ends by cones, one of which is truncated and serves to hold either the black surface or a diaphragm permitting the passage of the radiation from the ideally black interior of the cylinder. Steam is admitted through the pipe I and issues by O after circulating round the cylinder. The results show that the emissivity of lampblack increases much more rapidly with the thickness than does that of platinum black. The maximum for the former is attained at 30 mgr. per sq. dm., that of the latter at about 80. The maximum of intensity of the normal spectrum at 100° lies at about 8 m. For the short waves of the visible spectrum the absorption is much higher than for those of the maximum of absolute intensity. Both substances in layers of sufficient thickness sensibly obey the Stefan-Boltzmann law, and a considerable divergence from it means either a radiating layer of insufficient thickness or an insufficiently coated bolometer. For very long waves, both substances fail on account of their failure to absorb such waves. But for general purposes, platinum black is superior to lampblack, not only on account of its higher absorptivity and conductivity, but also because its deposition may be accurately governed by the electrolytic conditions. E. E. F.

809. *Distribution of Energy in Gases.* **E. Liveing.** (Cambridge Phil. Soc. Proc. 10. pp. 38–40, 1898.)—Some years ago Liveing and Dewar observed a very strong, diffuse, and easily reversed ray, with wave-length 2535·8, when mercury was introduced into the electric arc. Recently the author found that the same ray was produced by mercury heated in a flame of cyanogen burning in oxygen, which is nearly the hottest flame known. Another ray developed in the flame was that at 4358 in the indigo-blue. The emission of these two rays in a flame where the stimulus appears to be only the high temperature is a fact of some interest with regard to the atomic theory of gases. It proves that part of the heat communicated to the mercury is transformed into vibratory motion which affects the ether; and the true inference from the peculiar ratio of the specific heats of mercury vapour appears to be that, at the temperature at which this ratio is measured, the amount of heat converted into vibratory motion is very small compared with the amount which remains as heat. Experiments with a mixture of chlorine and hydrogen enclosed in a Kundt's tube made to sound by the usual method showed that at the temperature of the compressed gas in a sound-wave no sensible fraction of the heat is converted into vibratory motion, since no combination of hydrogen and chlorine took place. Still, this does not hold for higher temperatures, and so we must abandon the hypothesis that in gases energy communicated to the molecules is distributed equally in all the degrees of freedom. The hypothesis of gaseous atoms in the shape of rigid spheres is also disposed of since such atoms could not acquire any vibratory or internal form of motion from energy communicated to them as heat. It is possible that a chemically monatomic molecule may have, though it is not probable that it really has, a simpler constitution than a chemically complex molecule, and so may have not so many degrees of freedom as the latter, but still a plurality of degrees. E. E. F.

SOUND.

810. *Notes of High Frequency*. **F. Melde.** (Wied. Annalen, 67. 4. pp. 781–793, 1899.)—The methods for determining the pitches of high notes may be classified as subjective and objective. Among the subjective methods, one operates by direct comparison by the ear, and the other by the observation of difference tones. Both methods fail at very high pitches. Among the objective methods, one operates by a direct tracing of the vibration upon a surface moving at a known speed. In another two vibrations, one of a known and the other of the unknown pitch, are traced side by side. A photo-vibrographic method was devised in 1876 by S. T. Stein. Another was recently used by Appunn (see Abstract No. 445) for demonstrating the correctness of the pitches indicated on his small pipes. The author admits him to have proved that point, but maintains that his small forks have wrong pitches assigned to them. The author proceeds to give some further particulars of his own resonance method, which consists in transferring the vibrations to a rod sprinkled with fine sand. In conclusion, he points out the exceedingly great sensitiveness of flames to notes, and more especially to notes of the highest pitches. If an effective method would be devised for photographing their changes, and making them discriminate between various pitches, a very valuable means for studying high pitches would be available. E. E. F.

811. *Velocity of Sound*. **A. Leduc.** (Comptes Rendus, 127. pp. 1201–1203, 1898.)—This paper on the velocity of sound in air at 0° C. contains a criticism of corrections to be applied to the results of Violle and Vautier, and a defence of the value obtained by the author himself. J. B. H.

ELECTRICITY.

812. *Electromagnetic Theory.* **O. Heaviside.** (Electrician, 42. pp. 183–185, 1898, and pp. 410–412, 1899.)—Continuation of a series of articles on this subject. EDITOR.

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813. *Electrostatic Lines of Force.* **V. Boccara.** (N. Cimento, 8. 4. pp. 406–408, 1898.)—A curious method of demonstrating the lines of force in a gap between ball and ball, between ball and disc, or disc and disc, or point and disc, by smearing the terminals with liquid, say castor oil. When the electric machine is set at work, spray flies between the terminals in such a way as to demonstrate the directions of the lines of force. A. D.

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814. *Brush Discharge.* **E. H. Cook.** (Phil. Mag. 47. pp. 40–57, 1899.)—The phenomena considered are produced by the discharge of positive or negative electricity from a point connected to a Wimshurst machine. The author gives diagrams showing the shape of the positive brush for differently shaped pointed conductors, and points out that whereas the positive brush starts at a slight distance from the conductor the negative one begins on the conductor, except in rarefied gases. Measurements of the force of the wind from points are given, in which the repulsion of a balance pan by the discharge is observed; the results show that the positive brush exerts a slightly greater force for the same potential, and the force is felt by a light vane at a greater distance, than in the case of the negative brush. After referring to the effect of the brush in charging distant conductors the author describes experiments on the formation of ozone and the oxidation of ferrous salts by the brush discharge, from which it appears that the negative brush has by far the greater chemical action. A discharge from a copper point close to the surface of nitric acid does not cause the acid to receive any observable trace of copper; the points apparently do not disintegrate.

Experiments made with photographic plates show that the source of the actinic rays, as determined from the sizes of shadows of objects between the plate and the point, is the point itself and does not coincide with the origin of the visible brush. Photographic effects are produced after reflection, either from a metallic or a glass mirror. Other points of similarity to light are noted; measurements of the comparative intensities of candle-light and the discharge indicate that although the latter is of small illuminating power it is relatively rich in actinic rays. J. L. H.

815. *Electrical Discharge in a Magnetic Field.* **A. Broca.** (Journ. de Physique, 7. pp. 710–717, 1898.)—The author describes his experiments on the discharge with Crookes tubes and also with gases under ordinary pressure, and comes to the conclusion that there exists two sets of kathode rays—those of the first kind which follow the trace of a helix described round the direction of the lines of force, and those of the second kind which follow the direction of the lines of force. His experiments support the view of Crookes as to the nature of kathode rays. These seem to consist of assemblages of molecules identified with those of luminous sources. Experiments on the arc discharge corroborate this view. The material motions which produce the emission of radiations from an incandescent gas and those of the kathode rays in a Crookes tube appear to the author as two phenomena of the same order, but different through the form of the motions, the different forms of the electric discharge in gases presenting all the intermediate cases between the two extreme ones. J. J. S.

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816. *Cooling Effect of Gases traversed by Electric Discharge.* **E. Villari.** (N. Cimento, 9. pp. 77–87, 1899.)—The passage of electric sparks through gases causes them to produce a cooling effect on a platinum spiral in the neighbourhood of the sparks. If the spiral is heated by a current the resistance decreases, and this decrease furnishes a means of measuring the cooling effect. Experiments are described in which the current through the spiral is maintained constant by adding a variable external resistance to compensate the decrease in the resistance of the spiral. It is found that the change of resistance is small when the temperature of the spiral is low (corresponding to feeble currents); it increases with increased currents up to a maximum, beyond which it diminishes again. These results are obtained, with varying degrees of difficulty, in the case of oxygen, hydrogen, coal-gas, and carbon dioxide. The cooling action is increased on making the sparking more intense by using a larger primary current in the induction coil; an increase in the capacity of the condenser connected to the secondary circuit has, however, the opposite effect. Diminution of the pressure of the gas results in a diminished cooling, small at first but very marked when the pressure is only a few millimetres of mercury.

In a later series of experiments, using screens and reflecting surfaces suitably arranged between the spark-gap and the spiral, it is shown that the cooling is due to the impact of cold gas particles against the hot spiral, the particles being projected from the spark terminals. That such mechanical movements exist is demonstrated by the behaviour of tobacco smoke introduced at the bottom of the bell-jar in which the experiments are conducted. As soon as the sparks pass, the smoke is violently agitated and diffuses throughout the whole of the jar. On the other hand, a current of gas, through which sparks have been previously passed in another vessel, produces no greater effect than unelectrified gas.

The behaviour of nitrogen peroxide is anomalous. It produces a heating of the spiral, and it scarcely disturbs tobacco smoke lying at the bottom of the bell-jar. This action is not attributable to its density, because bromine, which is much more dense, is similar in behaviour to the other gases examined. The author calls attention to differences in the mode of diffusion of smoke through different gases; such diffusion is not directly related to the density of the gas. J. L. H.

817. *Residual Phenomena in Crookes Tubes.* **A. Sandrucci.** (Roma, R. Accad. Lincei, Atti, 8. pp. 108–115, 1899.)—The apparent after-action, the continued emission of kathode rays in high-vacuum tubes after the induction coil has ceased working, are imitated by unipolar effluvia; it appears to be due to an action in the existing apparatus. It depends on the tube and on the degree of vacuum and is sensitive to external electrostatic charges. Experiments in progress. A. D.

818. *Kathode and Röntgen Rays and Atomic Dimensions and Density.* **G. Guglielmo.** (N. Cimento, 9. pp. 131–142, 1899.) —Different means of measuring the diameters of molecules may be resolved into means of measuring the intensity of the circum-molecular field of force at different distances from the centre—and therefore different methods do not necessarily yield identical results. J. J. Thomson, W. Wien, and Lenard have shown reason for believing that the kathode rays consist of particles much smaller than a molecule, and moving with a velocity little less than that of light. The aggregates of such particles known as chemical atoms or as molecules seem to present the same obstructing area as the sum of the areas of the particles themselves; so that the kathode rays must freely traverse a molecule; and atoms of different atomic weights seem to consist of similar such particles, in larger or smaller aggregations. The diameter of the particles, from Röntgen ray absorption data, works out as of the order 1×10^{-11} and the absolute density about 80,000 kgr. per cubic cm. But this diameter really represents the effective obstructive area during the passage of kathode rays; and may be smaller, since the obstructive area covered during the passage is affected by the transverse vibratory movements of the particle; which consideration harmonises with the increase in the absorption brought about by higher temperatures, electric excitation, or impact of luminous waves. Kathode rays of smaller velocities are more affected by the obstruction offered by the particles they have to pass, and the absorption is accordingly greater. The

absorption of Röntgen rays is not sufficient to be consistent with their being flights of material particles; and they must be ether-perturbations, wanting in periodicity. A filament of glass rendered fluorescent by kathode rays appears blurred when looked at through a thick stream of kathode rays, at right angles to their track; which would point to ether-perturbations along the course of these intervening kathode rays. A. D.

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819. *Phase of Hertzian Oscillations.* **M. Abraham.** (Wied. Annalen, 67. 4. pp. 834–841, 1899.)—In discussing the apparent anomaly that near the point of radiation the magnetic component of a Hertzian wave should have an infinite velocity, the author shows during the proper oscillations of a solid of revolution, which are symmetrical to its axis, the phase of the magnetic force is propagated with infinite velocity into the surrounding space from the surface of the conductor, but that with increasing distance its velocity approaches asymptotically to the velocity of light. Of course it must not be supposed that the "phase" precedes the disturbance in space. The phase calculated for any one point only applies to it from the moment that the state of damped periodic oscillation has been established there. Now, since the disturbance is always propagated with the velocity of light, it follows that the wave emitted proceeds with varying phase. As regards a rod conductor, the oscillations at a great distance are the same as if the phase of magnetic force had traversed a path equal to half the length of the rod with infinite velocity.

E. E. F.

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820. *Neugschwender's Wave Detector.* **E. Aschkinass.** (Wied. Annalen, 67. 4. pp. 842–845, 1899.)—Instead of a narrow gap in a silver-on-glass mirror, as used by Neugschwender (see Abstracts, No. 567, 1899), the author employs two bent copper wires with pointed ends, which lightly touch each other. When immersed in methyl alcohol or in air these wires show the ordinary coherer action. But when they are immersed in water, or, better still, when a drop of water is put on the junction, electric waves produce an increase of resistance which continues as long as the waves impinge, and ceases when they cease. The same effect is produced in an ordinary coherer when the filings are wetted. But in both cases the promptness with which the original conductivity is restored is impaired by a prolonged action of the waves. This suggests some temporary modification of the conducting substance, which is gradually reversed on withdrawing the modifying influence. The fact that the galvanometer shows a deflection even after the current is withdrawn indicates polarisation. There is also a kind of fatigue. When waves pass in quick succession, they must be stronger and stronger to produce

the same effect, unless the indicator is artificially shaken. The most exact indications are given when the galvanometer current is comparatively strong. E. E. F.

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821. *Electro-capillary Phenomena.* **S. W. J. Smith.** (Roy. Soc. Proc. 64. pp. 253–255, 1899.)—A discussion of the Lippmann-Helmholtz theory of the capillary electrometer and a description of experiments which support the view that the first assumption of the Lippmann-Helmholtz theory is true and that the second is not. (Cf. on this subject Phys. Soc. Abstracts, No. 667, 1896; S. Meyer's experiments.) J. J. S.

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822. *Electrothermal Relations.* **W. Voigt.** (Wied. Annalen, 67. 4. pp. 717–740, 1899.)—The author gives the complete formulæ of his theory of the Ettinghausen-Nernst thermomagnetic E.M.F.s and their inversion, the galvanomagnetic heat currents. E. E. F.

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823. *Damping of Galvanometer Needles.* **H. Lemke.** (Wied. Annalen, 67. 4. pp. 828–833, 1899.)—The author shows that Schering's formula for the period, amplitude, and logarithmic decrement of a magnetic needle subject to a damping action may be simplified by regarding the motion of the needle as the sum of three simple damped oscillations. For the period he obtains an equation of the type—

$$T=\frac{\pi}{\beta}-\left(\frac{C_1}{C\beta}\sin D_1+\frac{C_2}{C\beta}\sin D_2\right)\left(e^{-\frac{2\epsilon\pi}{\beta}}-1\right)$$

E. E. F.

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824. *Resistance of Lead Amalgams at Low Temperatures.* **G. W. Gressman.** (Amer. Soc. Proc. 47. pp. 117–118, 1898.)—Amalgams were made containing various proportions of lead, ranging from 25 per cent. lead to pure mercury. The specimens were contained in little U-tubes of bore from 1 to 2 mm., and were cooled to a temperature below their freezing-points by a bath of ether and carbonic snow. The freezing-point of the amalgam was very sharply indicated by a sudden change in the resistance, the resistance of the solid amalgam being sometimes only one-fifth that of the liquid. The temperature coefficients of the amalgams between ordinary temperatures and the freezing-point was found to be nearly constant. The more lead in the amalgam the lower the temperature coefficient, which was extremely small in the case of the 25 per cent. amalgam. This amalgam, which is only

semi-liquid, shows a strange break in its resistance curve near 30° the coefficient being apparently positive for temperatures below, and negative for temperatures above this point. E. C. R.

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825. *Measurement of Resistances containing Earth Currents.* **R. R. Black.** (Electrician, 42. pp. 416–417, 1899.)—An adjustable resistance R is put in series with the resistance x, to be measured, and it is connected to a Wheatstone's Bridge in the usual manner. The adjustable arm D is adjusted to give a balance, the battery is then reversed, a balance being again obtained by altering R to R_1, then—

$$x=\frac{A}{B}\cdot D-\frac{R+R_1}{2}$$

As a rule it is best to make D about 25 per cent. higher than the estimated value of $\frac{B}{A}x$, and obtain a balance in each case by adjusting R. E. C. R.

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826. *Raymond-Barker's Insulation Test for Cable Joints.* **A. D. Constable.** (Elect. Rev. 43. pp. 37–40, 1898.) (See 1898, Abstract No. 932.)—An illustrated description of a trough applicable to the test, and hints are given for intercepting possible leakage. An analysis is made of the electrical conditions, both of the simpler test and of the absolute *null* method, using Thomson-Varley slides. The insulation of the joint may not only be proved satisfactory or the reverse, but may be worked out in megohms. One of the condensers may be dispensed with.

M. O'G.

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827. *Thermal Ammeter.* **C. Camichel.** (Séances Soc. Franç. Phys. 1. pp. 61–65, 1898.)—The thermal ammeter devised by the author (see 1899, Abstract No. 118), and recently improved, consists of a U-tube filled with mercury, and with one of its branches slightly drawn out in the middle. Into the narrow portion is introduced a mercury thermometer whose bulb is slightly less in diameter than the internal diameter of the tube. Two platinum electrodes plunge into the branches of the U-tube, and serve to convey the current to be measured. The heat developed is almost all concentrated round the thermometer, and the rise of the latter within a given time indicates the current strength. In the improved pattern, the U-tube is narrowed at its lowest portion, so as to produce a thin thread of mercury there. The thermometer bulb is made to enclose this thread, and thus measures the heating without loss by radiation. The heating is

directly proportional to the square of the current. The apparatus as constructed measures currents from 1 to 0·05 ampere within 1 or 2 per cent. Its indications are extremely constant.

E. E. F.

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828. *Commercial Potentiometers.* **Gosselin.** (Soc. Int. Elect. Bull. 15. pp. 246–268, 1898.)—This paper gives the principles of the potentiometer as applied to the measurement of E.M.F.s, potential differences, and currents, and a description of the potentiometers devised by G. Chaperon, R. E. Crompton, Elliott Bros., Nalder Bros. and Co., Janssen and Fiugner, of Hanover, &c. The paper is illustrated with skeleton diagrams of most of the forms, as well as illustrations of the complete apparatus.

E. C. R.

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829. *Alternate Current Arcs.* **W. Duddell** and **E. W. Marchant.** (Instit. Elect. Engin. Journ. 28. pp. 1–106, 1899.) This paper describes experiments made on the alternate current arc by means of oscillographs. The oscillograph is a form of d'Arsonval galvanometer of very short periodic time and critical damping; it is formed by stretching, in a narrow gap between the poles of an electromagnet, two parallel conductors formed by bending a metal strip over a pulley; at the bottom of the gap the ends of the strip are clamped to a block, and a bridge piece at the top of the gap presses against the strips. The current to be measured flows up one strip and down the other, thus causing one to move forward and the other backward, and turning a mirror attached to them through an angle which, if small, is proportional to the current. The necessary damping is obtained by immersing the strips and mirror in a chamber filled with oil. The spot of light from the oscillograph mirror was examined by a rotating mirror or thrown on to a rapidly moving photographic plate.

The paper is very fully illustrated with curves from photographs obtained by this method, which give the P.D. at the terminals of the dynamo, that at the terminals of the arc, and the current. The following are some of the results obtained:—

1. If a resistance in any alternate current circuit is replaced by an arc which transmits the same r.m.s. current, the wave forms of P.D. between its terminals and the current through it are no longer the same, and the r.m.s. value of the P.D. between its terminals is increased.

2. With high voltage solid carbons and *small* self-induction in the circuit, the P.D. arc wave is flat-topped, with a high front and smaller back peak; the current remains small for a considerable part of the period; the power factor is low, and the arc is unstable.

3. With high voltage solid carbons and *considerable* self-induction in the circuit, the P.D. arc wave is rectangular, with much

smaller peaks; the current no longer remains small for any sensible time; the power factor is higher, and the arc is much more stable.

4. With soft-cored carbons, the reaction is generally small; the P.D. arc wave has a dent in the front side; the power factor is nearly unity, and the arc is very stable.

5. With one solid and one soft-cored carbon, the reaction is intermediate. At any instant the nature of the carbon which is positive determines to a large degree the reaction at that time.

6. Increase of arc length with solid carbons first increases both peaks in the P.D. arc wave until the hissing-point is reached; further increase of length produces a high front peak and no back peak. Very long arcs with all kinds of carbons give a P.D. wave with a large front peak. The power factor, with solid carbons, decreases with increase of length up to the hissing-point, and then increases; with cored carbons the power factor is generally higher for longer arcs.

7. The large front peak on the P.D. wave for long arcs is due to the high resistance of the gaseous column after each extinction of the arc.

8. The distribution of the fall of P.D. in the alternate current arc is similar at any instant to that in the direct current arc.

9. Resistance in series has little effect on the P.D. arc curve, but causes the current wave to become more like the open-circuit wave of the particular machine used; the larger the resistance the greater this effect.

10. Lowering the frequency increases the reaction, increases the peaks with the solid carbon arc, and the time during which the current is small, in all cases. It reduces the power factor and stability, but improves the efficiency.

11. With transformers having a very small magnetic leakage, *i.e.*, designed for constant secondary P.D., the distortion of the secondary wave forms is accompanied by a similar distortion of the primary wave forms. With transformers having a large magnetic leakage and intended to give constant current the distortion is not appreciably transmitted from the secondary to the primary circuit.

12. The distortion of the wave forms by the arc occurs with all makes of carbons, the amount depending on the hardness and impurities contained.

13. Foreign bodies in the arc generally reduce the reaction, and lower the r.m.s. value of the P.D. for a given length and current. Small quantities of the salts of the alkali metals may be used to lower the voltage at which the arc burns, but they probably also reduce the efficiency.

14. Arcs between carbons and metals are generally unidirectional, the currents flowing much more easily from the metal to the carbon. The more rapid cooling of one electrode facilitates the flow of current from it, and resists the flow towards it.

15. Enclosing the arc increases the reaction, the front peak on

the P.D. arc wave becoming more marked. The r.m.s. value of the P.D. is raised, and the power factor reduced.

16. The reaction still occurs when the arc is only part of the load on the alternator.

17. The reactions are more marked with arcs in series.

18. With arcs between unequal carbons the current is larger when the larger carbon is positive.

19. When the direct current arc hisses, the P.D. and current vary very rapidly; these variations in the case of a solid carbon arc have a frequency of 1,000 per second, and take place so that an increase of current is accompanied by a reduction of P.D.

20. In all questions relating to the alternate current arc the distortion of the wave forms by the arc must be taken into account, as these distortions considerably affect the efficiency, the stability, and the power factor. E. C. R.

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830. *Electric Arc.* **F. Eichberg** and **L. Kallir.** (Wien. Akad. Sitzber. 107. pp. 657–680, 1898.)—This paper is somewhat fuller than that by the same authors which appeared in Eclair. Elect. 17. pp. 560–566, 1898. (See 1899, Abstract No. 679.)

Results are given of experiments with alternating arcs between electrodes of carbon and electrodes of iron, aluminium, copper, and nickel. With all these metals the apparent constant currents and constant differences of potential in the direction metal-carbon are approximately the same. This fact leads the authors to the conclusion that the cause of the excess current in one direction cannot be an opposing E.M.F. in the arc due to the metal and carbon electrodes, as this opposing E.M.F. would vary for different metals. They conclude that the cause is due to greater resistance in the one direction than in the other through the arc.

Photographs of the different arcs are given in the paper. J. B. H.

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831. *Magnetic Induction in Electrical Measuring Instruments.* **A. Campbell.** (Phil. Mag. 47. pp. 1–18, 1899.)—Two methods of measurement were principally used. 1. When the magnetic fluxes were not alternating, a search coil in circuit with a ballistic galvanometer either had the flux suddenly reversed in it or was pulled quickly out of the field. 2. When the flux was alternating, the search coil was connected to a resistance coil laid along one set of junctions of a minute thermopile, which was connected to a sensitive galvanometer. For a given frequency the mean square of the P.D. at the terminals of the search coil was proportional to the deflection on the galvanometer. If the resistance of the search coil be negligible and the flux follows the sine law

$$v_2 = 10^{-8} \times 2\pi n N_2 B S_2$$

where v_2=voltage shown by galvanometer, n=frequency, N_2= number of turns in search coil, S_2=area of search coil, and

$$B = \sqrt{\text{mean square of flux.}}$$

The values of B are given for a large number of instruments, including a variety of electric supply meters.

Experiments made with a Siemen's electro-dynamometer turned to the four points of the compass gave a maximum variation of 2·1 per cent.

In a Weston voltmeter a variation of 0·1 per cent. was detected in the higher readings when its position with respect to the earth's field was altered. E. C. R.

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832. *Florian's Mariner's Compass.* **E. Gelcich.** (Zeitschr. Instrumentenk. 18. pp. 339–340, 1898.)—To make the compensation of compasses as simple as possible, H. Florian employs invariable "correctors" for the vertical fore-and-aft plane and the thwart plane respectively. When the correctors are vertical their deviating effect is nil. The deviation of the needle increases with the inclination of the correctors to the vertical. Each corrector is provided with a divided circle on which the amount of artificial deviation is marked against each angle of inclination.

Florian's "deflector" is based upon the principle that if a bar magnet is mounted on land in a place free from iron above a compass needle in such a manner that the centres of the magnet and the needle are in the same vertical, and the magnets themselves make an angle of 45°, the directing force of the needle becomes invariable when the deflector is made to deflect the needle by 90°. A scale indicates for every horizontal intensity the position corresponding to the suitable position of the deflector on land. If then the apparatus is brought on board an iron vessel, the needle will show a deflection different from 90°. The deviation constants are thus easily determined. To avoid both octantal and sextantal deviation, there must be four needles, and the angles they make normally with the NS lines must be 52·5° and 7·5° respectively. E. E. F.

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833. *Magnets of Different Steels.* **A. Abt.** (Wied. Annalen, 66. 1. pp. 116–120, 1898.)—This paper contains a comparison of the magnetic moments of similar magnets made of different steels and magnetised in the same fields, the fields being increased step by step until all the magnets were saturated. The magnetic moment of the magnet of Wolfram steel is about twice that of any of the others. It loses its magnetism, however, faster than some of the others, losing 26·5 per cent. in 122 days. J. B. H.

834. *Hysteresis and Temperature.* **A. M. Thiessen.** (Amer. Assoc. Proc. 47. pp. 115–117, 1898.)—A preliminary communication containing an account of some experiments undertaken to ascertain the law connecting hysteresis loss with temperature for temperatures below the freezing-point. It is known that, for temperatures above 0° C. the hysteresis loss for a given maximum of B decreases with rise of temperature. On the other hand, Fleming and Dewar have found that, at the temperature of liquid air the hysteresis loss in soft Swedish iron is practically the same as at ordinary temperatures. The author's experiments show that, for temperatures between about $-70°$ C and 0° C. the hysteresis loss for a given induction decreases with rise of temperature. The measurements were made by the ballistic method, the specimens being in the form of rings about 5 cm. in diam. and 1 sq. cm. in section. The lowest temperature was obtained by immersing the ring and magnetising coil in a bath of ether containing dissolved CO_2 (a layer of gutta-percha being used as a protective covering). Three specimens were tested: one of soft wrought iron, another of tool steel, and a third of nickel steel. In each case there was a decrease of hysteresis loss with rise of temperature. A. H.

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835. *Hysteresis.* **F. Niethammer.** (Wied. Annalen, 66. 1. pp. 29–48, 1898.)—The magnetic hysteresis in iron is here investigated under the following different conditions: 1. When the magnetisation is increased in the ordinary step by step method, the induction being measured ballistically. 2. When the magnetisation is produced by alternating currents, the hysteresis being taken as the ratio of the maximum induction to the maximum field. 3. When the iron is rotated in a uniform magnetic field. 4. As in 1, but with no reversal of current, so that the field only varies from a maximum to zero and is never reversed.

The principal portion of the paper is devoted to the magnetisation by alternating currents. An iron ring is used, which is built up of 400 ring plates insulated from each other by paper. The sectional area of the ring is 135 cm.^{2}, the volume 925 cm.^{3}, and the mass of iron 72·17 kg. The ring is wound with 96 turns, uniformly distributed on the circumference.

The main electric circuit contains, besides the magnet, an electrodynamometer, a wattmeter, and a non-inductive resistance. A multicellular voltmeter measures the effective E.M.F., and a Joubert disc and ballistic galvanometer serve to determine the curves of E.M.F. and current.

The maximum value of H during a period is obtained from the geometry of the ring magnet and the maximum value of the current during the period. Calculation shows that owing to the ring form of magnetic circuit, H may vary by 2 per cent. over the section.

The maximum induction during a period is obtained from the curve of E.M.F. since the total induction:—

$$B6 = \frac{1}{2n}\int_0^\pi edt.\ 10^8$$

from which B is found. In the paper, tables are given containing the values of B, H, μ, N (frequency), A (the wattmeter reading) and cos ϕ (the ratio of A to the product of effective current and E.M.F.).

The B-H curve for $N = 37$ lies above that for $N = 59$, and both lie much below the magneto-static curve determined as in 1. This lowering of the curve with increase of frequency cannot be accounted for by Foucault currents or by shielding, and the author attributes it to a real diminution in the value of the hysteresis with increase of frequency.

To determine Steinmetz coefficient the value of A is corrected for the energy lost in Foucault currents in the iron. The total energy lost is—

$$A = V\{\eta N B^{1\cdot 6} + \epsilon N^2 (C_a B)^2\}\ 10^{-7}$$

where the first member is the energy lost by hysteresis and the second that lost by Foucault currents. Taking the results of experiments with two different values of N the frequency, the second member of the equation can be eliminated between the two equations and a value of η obtained. The paper gives values of η corresponding to values of B from 1400 to 13600. These are by no means constant, $\eta = 0{\cdot}00259$ for $B = 1400$ then for $B = 2700$ $\eta = 0{\cdot}00291$; η then falls to 0·00257 for $B = 7600$ from which point it continues to rise with B, being 0·00368 for $B = 13600$.

Experiments are made with E.M.F. curves of different forms, but the form does not seem to have any great effect on the results; departures from sine curves tend, if anything, to bring the B-H curves slightly nearer the magnetostatic curve.

The magnetostatic experiments give variations in the values of η which correspond with those for alternating currents, but the values of η themselves are smaller for the magnetostatic experiments than for the others.

The results of magnetostatic experiments without reversal of the current are given for values of H from 1·8 to 27, the corresponding values of $\frac{B_2 - B_1}{2}$, varying from 278 to 2010, and η from 0·00192 to 0·00686.

For the experiments on rotation in a magnetic field the armature of a continuous current dynamo is used. It is driven by a motor, and the energy required to drive the motor is noted both when the dynamo armature is in and when out of, a magnetic field. The energy lost by Foucault currents is eliminated from the results of two series of experiments with different speeds of rotation. The values of η obtained vary from 0·00305 for $B=14{,}010$ to 0·00119 for $B=4495$. Vibration seems to have no effect on the loss due to hysteresis. J. B. H.

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836. *Magnetic Susceptibility of Water.* **G. Jäger** and **S. Meyer.** (Wied. Annalen, 67. 3. pp. 707–713, 1899.)—The magnetic susceptibility was determined by two additional methods. A glass tube was attached to one arm of a balance and exposed to a magnetic field. After determining the magnetic pull upon the empty tube, it was filled with water and the new magnetic pull was observed. It was found to be $-0·146$ g. with a tube 1·5 sq. cm. in internal sectional area. The values obtained for the susceptibility were $-0·665\times10^{-6}$ on an average. Manganese chloride of sp. gr. 1·160 at 15° gave $+20·8\times10^{-6}$, and ferric chloride (42·2 per cent.) gave $+47·47\times10^{-6}$.

Another method consisted in observing the velocity of efflux of water from a narrow orifice when that orifice was brought into a strong magnetic field. This was, however, only applied successfully to the measurement of the susceptibility of ferric chloride solution. The value thus obtained was $47·1\times10^{-6}$, which agrees with the last result remarkably well. All the methods hitherto employed by the authors give results not differing by more than 2 per cent. The mean result for water is

$$k = -0·689\,(1-0·0016t)\times10^{-6}.$$

E. E. F.

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837. *Chemical Action of Magnetism.* **E. Jahr.** (Elektrochem. Ztschr. 5. pp. 177–180, 1898.)—Dry photographic plates are not affected by a magnet; but if they be brought within 1 mm. of the polar ends of a bundle of 40 magnetised steel wires each 10 cm. long by 1 mm. thick, while the sensitive surface is immersed in the developer (pyro 2, sulphite soda 15, carbonate potash 6, water 500) or even in distilled water, with exposures from 1 to 10 minutes, the plate is found to have been affected. Reproductions of the negatives are given in the paper. Electromagnets act similarly. Unmagnetised iron has no effect. The metal was kept, by wax and waxed paper, from contact with the liquid. A. D.

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838. *Meteorological and Magnetic Phenomena.* **v. Rijckevorsel.** (Phil. Mag. 47. pp. 57–65, 1899.)—This is a continuation of the work referred to in Abstract No. 900 (1898). The author has drawn curves showing the annual range of tempera-

ture, horizontal force, declination, vertical force, rainfall and barometric pressure for various stations in Europe. He finds a similarity between the curves for the various elements. Thus the maxima and minima are in general repeated in all the curves, though they sometimes occur earlier in some than in others.

From a consideration of the temperature curves for the various stations in Europe, particularly of the minimum in June and the maximum in July, the author concludes that the June minimum is due to some disturbing cause travelling from the West coast of Scotland southwards, and the July maximum to a similar disturbing cause approaching Europe from the South.

The author concludes that there is some common cause which rules all the meteorological and magnetic phenomena, and which influences them all in a similar way and almost simultaneously.

W. W.

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839. *Magnetic Inclination Deduced by Magnetisation of Clay.* **G. Folgheraiter.** (Roma, R. Accad. Lincei, Atti, 8. pp. 69–76, 1899.)—The author shows how observations of the free magnetism of certain cylinders, which have been baked, whilst subject to the action of the earth's magnetic field, can be applied to calculate the directions of the magnetic axes of the cylinders, and hence to estimate the magnetic inclination. The estimated values only differ by one or two degrees from the true values. He obtains equally good results with specially prepared vases and amphoras.

The bearing on the determination of the dip in ancient times is obvious. A. Gs.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

840. *Atomic Weights.* **F. G. Wiechmann.** (Science, 9. pp. 23–24, 1899.)—The author gives the values which are recommended for adoption in analytical practice by a commission appointed by the German Chemical Society, consisting of H. Landolt, W. Ostwald, and K. Seubert. Some of these are given below. The last decimal place may be regarded as accurate except in the cases of nickel, bismuth, and tin.

Name.	Atomic Weight.	Name.	Atomic Weight.
Aluminium	27·1	Iron	56·0
Antimony	120	Lead	206·9
Arsenic	75	Magnesium	24·36
Barium	137·4	Manganese	55
Bismuth	208·5	Mercury	200·3
Boron	11	Nickel	58·7
Bromine	79·96	Nitrogen	14·04
Cadmium	112	Oxygen	16·00
Calcium	40	Phosphorus	31·0
Carbon	12·00	Platinum	194·8
Chlorine	35·45	Potassium	39·15
Chromium	52·1	Silicon	28·4
Cobalt	59	Silver	107·93
Copper	63·6	Sodium	23·05
Fluorine	19	Strontium	87·6
Gold	197·2	Sulphur	32·06
Hydrogen	1·01	Tin	118·5
Iodine	126·85	Zinc	65·4

T. E.

841. *Recently Discovered Gases.* **W. Ramsay.** (Science, 9. pp. 273–280, 1899.)—The lightest fraction of atmospheric argon contains helium, argon, and a new gas, neon. These are separated by means of their different solubilities in liquid oxygen, helium being the least, argon the most soluble. The purest neon obtained had the density 10·04 and 10·19, and the refractivity 0·338 compared with air. The wave-lengths of the most important lines in its spectrum are 6402, 6383, 6335, 6267, 6218, 6164, 6143, 6096, 6074, 6030, 5853, 5401, 5341, 5331, 4716 (?), 4722, 4710, 4709, 4704. The heaviest fraction of atmospheric argon contains three gases—metargon, distinguished by giving the spectrum of carbon monoxide when mixed with oxygen, krypton, and xenon. The last, in an impure condition, has the density 32·5, and like argon possesses two spectra. By thrice-repeated fractional distillation of liquid argon, rejecting the

lightest and heaviest fractions, a purified sample was prepared which was again liquefied and distilled in six fractions. With the exception of the first, which contained a little neon, these had practically the same density and the same refractivity. The mean density was 19·96. (See 1898, Abstract No. 1370.) T. E.

842. *Twinning of Crystals.* **F. Wallerant.** (Comptes Rendus, 127, pp. 1250–1252, 1898.)—While, according to Mallard's law, crystals frequently twin so as to supply elements of symmetry deficient in their molecular network, the network of the twins being parallel and the molecules arranged symmetrically with reference to these elements, the author supposes that in other cases the orientation of the molecules in the twins is parallel, the networks being arranged symmetrically to elements of symmetry deficient in the molecules. Since a molecule, contrary to a network, may possess an axis of symmetry of any order (viz., five, &c.) very complicated systems are possible; fluor spar and marcassite are adduced as examples. B. B. T.

843. *Vapour Pressure of Solutions.* **C. Dieterici.** (Wied. Annalen, 67. 4. pp. 859–870, 1899).—The author examined the vapour pressures of aqueous solutions at 0° C. whose concentrations were between normal and decinormal solution. The error of method was great, since the accuracy depended upon the certainty with which two vessels, one containing water and the other the solution, could be brought to the same temperature. A difference of temperature of 0·0025° means a difference in vapour pressure of 0·001 mm. of mercury, and since the decrease of pressure of the decinormal solution of a non-electrolyte only amounts to about 0·008 mm. altogether, the results obtained are of little quantitative value. The author is, however, enabled to draw two general qualitative conclusions. The first is that within the concentrations specified no decrease of vapour pressure with decrease of concentration is observed in electrolytes. The second is that Raoult's law, which makes the decrease of vapour pressure independent of the nature of the solute, and simply dependent upon the number of molecules dissolved, does not apply to aqueous solutions of non-electrolytes. That, of course, does not exclude the possibility of both phenomena occurring at greater dilutions. E. E. F.

844. *Hydrogen and Platinum.* **A. Mior.** (N. Cimento, 9. pp. 67–76, 1899.)—Platinum goes on absorbing hydrogen up to about 8·4 times its volume, the process taking, say, eight months at ordinary temperatures, but being accelerated by warming the metal. When it has taken up this maximum, warming the metal will not induce it to take up any more. A. D.

845. *Heat Developed on Wetting Powders.* **G. Ercolini.** (N. Cimento, 9. pp. 110–116, 1899.)—The heat developed rises with successive additions of liquid up to a maximum, and on further additions of liquid the heat developed remains constant, and does not fall back as T. Martini asserts it does. A. D.

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846. *Dissociation of N_2O_4.* **A. Pochettino.** (Roma, R. Accad. Lincei Atti, 8. pp. 183–188, 1899.)—Values of k/c, the ratio between the two specific heats, found at various temperatures from 4° C. to 150° C., by sound-velocity measurements by Kundt and Wüllner methods. The value of the ratio increases with the temperature from 1·169 (for N_2O_4, at 4°.2 C.) to 1·300 (for NO_2, at 140° C.). The changes of value agree with the hypothesis that the gas at intermediate temperatures consists of mixtures of N_2O_4 and NO_2, according to Gibbs' law (Amer. Journ. Sci., xviii. p. 279, 1879) of gradual dissociation with increasing temperatures. A. D.

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847. *Properties of Aluminium.* **A. Ditte.** (Annal. Chim. Phys. 7. pp. 152–162, 1899.)—This paper deals with the difficulties experienced in getting aluminium to enter into chemical combination, although its heat of combination shows that it should rank as a metal very easily acted on by acids, and one which should decompose water. This seeming immunity from chemical action is due to two causes: 1. The coating of alumina which forms so quickly on any fresh surface; 2. The film of hydrogen with which the aluminium is surrounded almost immediately after being put into water or acid. By arranging the conditions so as to prevent these from forming, continuous chemical action can be obtained.

The film of hydrogen can be got rid of by working in a partial vacuum, and, by suitably arranging the substances present, the formation of alumina may be prevented. For instance, aluminium in a solution of common salt would give aluminium chloride and soda with evolution of hydrogen, but the soda reacts with the aluminium chloride, giving alumina and common salt again; so the result is that only the water takes part in the action. If, however, we introduce acetic or some other weak acid to combine with the soda and prevent it reacting with the chloride, the solution of the aluminium continues so long as any free acid is present. The other cases dealt with can all be explained in a similar way. J. B. H.

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848. *Solution Theory of Iron and Steel.* **H. J. von Jornstorff.** (Engineering, 66. pp. 763–764, 1898.)—Roberts-Austen's experiments show that the eutectic alloy of iron and carbon, con-

taining 4·3 per cent. of carbon, freezes at 1130°. From solutions containing less carbon pure iron crystallises out, and from those containing more carbon graphite separates. Taking the absolute freezing-point of iron as 1873°, and its molecular heat of fusion as 20 (this latter number being very uncertain), the molecular depression of the freezing-point may be calculated by means of van't Hoff's formula. By means of this number and Roberts-Austen's freezing-point curve the author finds that the molecular weight of carbon dissolved in molten iron increases with the concentration from 24·54 to 31·27. The heat of dissolution of carbon in molten iron is also calculated from its solubility by means of a formula analagous to that applying to ordinary solutions, as 1419 cals. per gramme.

Similar calculations are made for silicon and carbon dissolved in molten iron, and for the separation of ferrite and perlite from solid solution, but the experimental data appear to be insufficient to give any reliable result. T. E.

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849. *E.M.F. and Heat of Formation of Alloys.* **M. Herschkowitsch.** (Zeitschr. Phys. Chem. 27. pp. 123–166, 1898.)—Part I.—*E.M.F. of Alloys.* Laurie's results were open to the objection that they were not always obtained with solutions containing a salt of one of the metals under examination. The author has therefore repeated them under more favourable circumstances, and by stirring the electrolyte and using a constant current-intensity, has obtained a fresh series of results. The method of observation, giving results accurate to 0·1 millivolt is described. In each of the experiments a series of binary alloys was examined, starting with one metal pure and gradually adding increasing proportions of the other metal in each successive test until the series ends with the other metal pure. Thus:—

Cadmium-Tin alloys opposed to cadmium in normal cadmium sulphate solution show practically the same potential difference from 100 per cent. Cd to the alloy with a molecular percentage of 2·7 Cd, the rise of potential then becoming more and more abrupt up to 100 per cent. Sn. The solubility of solid cadmium in solid tin is rather over 1 molecule per cent., whilst that of tin in cadmium is almost *nil.*

Cadmium-Lead alloys under similar conditions showed the beginning of the abrupt rise in P.D. when the Cd in the alloy had been reduced to 3·6 mols. per cent. The solubility of Cd in Pb is a little over 4 mols. per cent.

Cadmium-Bismuth alloys under similar conditions showed the same P.D. throughout the series. These solid metals are therefore scarcely, if at all, mutually soluble.

Zinc-Tin alloys opposed to zinc in normal zinc sulphate solution showed the first abrupt rise when the zinc had been reduced to 3·47 mols. per cent.

Zinc-Copper alloys under similar conditions showed a P.D. of about 5 millivolts from 100 per cent. Zn down to 69 mols. per cent. Zn, when it rapidly rose to about 700 millivolts for the alloy with 66 mols. per cent. Zn (*i.e.*, Zn_2Cu); beyond this point the curve of P.D. gradually becomes less steep, showing a P.D. of about 1,130 millivolts for pure Cu opposed to pure Zn. This and other observations explained confirm the view that the alloy Zn_2Cu is a chemical compound.

Zinc-Bismuth alloys under similar conditions show no sudden rise of potential until the Zn is reduced to 5·86 mols. per cent.

Zinc-Silver alloys under like conditions show a marked increase in P.D. when the Zn is reduced to 82·6 mols. per cent., and then an abrupt and great rise when the Zn is between 80 and 77 mols. per cent. There is every indication therefore that Zn_4Ag is a chemical compound.

Zinc-Antimony similarly shows a sharp rise at the point when the zinc is reduced to the percentage corresponding to $ZnSb_2$.

Tin-Copper alloys opposed to tin in saturated stannous chloride solution show one abrupt change of potential at the point corresponding to the chemical compound Cu_3Sn.

Tin-Silver alloys, similarly, gave the rise in P.D. with the compound Ag_4Zn; the absence of any abrupt change at the point corresponding to Ag_2Zn seems to negative the assumption based on observations of other properties that Ag_2Zn also is a true compound.

Copper-Silver alloys, opposed to copper in normal copper sulphate solution, show a gradual rise of P.D.

Part II.—*Heat of Formation of Metallic Alloys.* The heat of formation of certain alloys was determined on Hesse's principle and by a modification of Andrews' method. The pure metals alone were acted upon by bromine solution in a calorimeter under suitable conditions, which are described at length; and after applying certain necessary corrections, the heats of formation of the pure bromides are thus obtained. The metals after alloying are then treated with bromine in the same way. The difference between the heats of formation of the salts formed from an alloy of determined composition and those of the same weights of salts obtained from the unalloyed metals gives the heat of formation of the alloy under examination. Zinc and tin, cadmium and zinc, and copper and tin absorb heat in alloying, whilst copper-zinc forms an exothermic compound, the maximum heat evolved being given out when the metals are nearly in the proportion Zn_2Cu.

W. G. M.

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850. *Validity of the Dilution-Law.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 25. pp. 79–90, 1898.)—The author maintains: 1. That the Ostwald dilution-law is the true dissociation-law for *all* electrolytes. 2. That the Rudolphi-van't Hoff form is not a true dissociation-law. 3. That the latter only represents conductivity results in solutions of highly dissociated electrolytes owing to a

secondary circumstance, viz., the Joule heat produced during the passage of the current. 4. That for the same reason the electrical determination of degree of dissociation is incorrect. The author bases the arguments for 1 and 2 on a formula previously deduced by himself. Noyes has, however, shown recently that this formula is not correct (Zeit. Phys. Chem. 26. p. 699).

The arguments in favour of 3 and 4 may be sufficiently characterised by the fact that the Joule heat is supposed to heat up the ions and salt-molecules to a very much higher temperature than the surrounding water. It is only fair to say, however, that this paper has given rise to a controversy between van Laar and Noyes, and that this is still in progress. F. G. D.

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851. *Solubility of a Binary Electrolyte in a Solution of another having Different Ions.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 27. pp. 267–278, 1898.)—This paper is an application of the principles of the theory of ionisation to certain special cases. The author starts out from three sets of equations, viz.: 1. The analytical data of the solution (which involve the solubility to be calculated). 2. His own *Solubility-laws* (*i.e.*, constancy of the ionic "solubility-product" and of the amount of undissociated salt present in a solution, when the corresponding solid phase is in equilibrium with the solution). 3. The electrolytic dissociation-equations for the various possible electrolytes. Under 3 he employs for highly dissociated electrolytes the Rudolphi-van't Hoff equation in the more general form $\frac{C_1C_2}{C_0^{\frac{4}{3}}}$ = const., where C_1 and C_2 are the concentrations of the positive and negative ions, and C_0 that of the undissociated salt. Supposing now CD to be the binary electrolyte already present in the solution, and AB the one whose solubility therein is to be determined, the reaction occurring in the solution is AB+CD=AD+CB. The author then shows how the solubility of AB can be calculated by suitable approximation-methods in the following cases: 1. AD or CB highly dissociated. 2. CD and AD (or CB) highly dissociated. 3. AD or CB highly dissociated. Between the values so calculated and the results of experiments carried out by the author and his pupils there is a most satisfactory agreement. F. G. D.

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852. *Chemical Equilibrium between Amalgams and Solutions.* **A. Ogg.** (Zeitschr. Phys. Chem. 27. pp. 285–311, 1898.)—After some preliminary remarks on the Nernst theory of the equilibrium between metallic complexes and solutions, the author proceeds to investigate the equilibrium between metallic mercury and silver nitrate solution. The silver displaced from the solution dissolves in the mercury, and a state of equilibrium is reached,

where we have Mercury + Ionic Silver $\rightleftarrows$ Silver + Ionic Mercury. The author takes the active mass of the silver in this reaction as proportional to its concentration in the mercury, and the active mass of the mercury as constant. Hence if a = concentration of ionic silver, b = concentration of ionic mercury, c = concentration of silver in the amalgam, we obtain a/cb = const. or $a/c\sqrt{b}$ = const. according to whether mercury exists in the solution as a *monovalent* or *divalent* ion. The experiments of the author verify the *second* of the above formulæ. This result is confirmed by an investigation of the equilibrium between metallic mercury and a solution containing mercurous and mercuric nitrates, and by experiments on concentration cells and on conductivity, according to the well-known methods. Reference is also made to the freezing-point results of Canzoneri (Gazetta Chim. [2]. 23. 432, 1893). In the above experiments a solid amalgam is found to separate when the concentration of the silver in the mercury reaches a certain value. The author investigates its composition by methods analogous to those which are now generally used for hydrated salts, and finds it to be Ag_3Hg_4. A calculation of its heat of formation (7336 gr. cal.) and some measurements on the "decomposition – E.M.F.'s" of solutions of silver and mercurous nitrates conclude the paper. F. G. D.

853. *Equilibrium in Water—Alcohol—Succinonitrile System.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 27. pp. 95–122, 1898.)—Solutions of the above nitrile, either in water or alcohol, are capable of forming two layers, the separation-temperatures being 18·5° – 55·5° and 13° – 31° respectively. Therefore between 18·5° and 31° two cases are possible in the system of all three components: the separation may take place for all proportions of alcohol to water, or mixtures may exist which remain homogeneous on adding nitrile. The latter is found to be the case between 56·1 per cent. and 71·4 per cent. alcohol. Solubilities are determined from – 5° to 55°, and isotherms calculated from 4·5° to 18·5°. B. B. T

854. *Equilibrium in Water—Sal Ammoniac—Iron Chloride System.* **E. C. J. Mohr.** (Zeitschr. Phys. Chem. 27. pp. 193–221, 1898.)—The work of B. Roozeboom (Zeitschr. Phys. Chem. 10. 145) is extended to higher temperatures, curves being determined for 25°, 35° and 45°. Of these the first two are similar to that for 15° and show very slight increase in solubility of the double salt. The curve for 45° except for the disappearance of the hydrate $2FeCl_3.12H_2O$, which melts at 37·5°, is also similar. Two new double salts $FeCl_3\ NH_4Cl$ and $2FeCl_3\ NH_4Cl.4H_2O$ are discovered and are investigated crystallographically: the latter is regular and is the salt previously taken to be regular ferric

chloride. The solubility curve for the previously known double salt $FeCl_3\ 2NH_4Cl\ H_2O$ is such that, especially at high temperatures, evaporisation of a saturated solution may cause first a precipitation and afterwards resolution, as was observed for $PbI_2KI.2H_2O$ by Schreinemaker. B. B. T.

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855. *Pressure-Temperature Diagrams for Binary Systems.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 1–11, 1899.)—A discussion, from an abstract point of view, of the pressure-temperature relations in systems containing two independently variable constituents. The only novelty is that the partial-pressure curves for the two constituents are shown in the diagrams. No experimental work is given. The author considers the effect of a solvent action in the vapour phase, *i.e.*, an increase in the sublimation-pressure of one of the solid constituents due to the presence of the other in the vapour. He also considers the effect of solid solutions, and concludes by showing that there is no anomaly in the fact that solutions saturated with respect to anhydrous sodium sulphate have, when in the metastable or instable region a lower vapour-pressure than the stable solutions saturated with respect to decahydrate. F. G. D.

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856. *Cryoscopic Measurements of Sodium Mellitate.* **W. W. Taylor.** (Zeitschr. Phys. Chem. 27. pp. 361–363, 1898.)—Sodium mellitate, $Na_6C_{12}O_{12}+17H_2O$, being the sodium salt of a hexabasic acid should dissociate in very dilute solution into seven ions and the molecular depression of the freezing-point should approximate to seven times the normal value. The molecular depression observed is 3·77 times the normal value (1·87) in a solution containing 0·0277 gram molecule per litre, increasing to 5·92 times the normal value in a solution containing 0·00181 gram molecule per litre. T. E.

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857. *Cryoscopic Investigation of Derivatives of the Terpenes.* **W. Biltz.** (Zeitschr. Phys. Chem. 27. pp. 529–551, 1898.) Substances containing the hydroxyl group, when dissolved in benzene or naphthalene, give abnormally small molecular depressions of the freezing-point; this indicates the existence of polymeric molecules, the degree of polymerisation increasing with the concentration. The author finds that this is strikingly exemplified by the oxygen derivatives of the terpenes, among these the ketones, aldehydes, and oxides show no tendency to polymerise whilst the alcohols all do so. The polymerisation is greatest with primary, least with tertiary alcohols. T. E.

858. *Exact Cryoscopic Measurement.* **F. M. Raoult.** (Zeitschr. Phys. Chem. 27. pp. 617–661, 1898.)—The errors of the thermometer are first considered. The apparatus used for the freezing-point determination consists essentially of a glass tube completely surrounded by a mantle filled with ether, the temperature of which can be exactly regulated by blowing air through it. Surrounding the bulb of the thermometer is a helix of platinum foil, which rotates at constant velocity with the thermometer, and acts as stirrer. In making a measurement the solution is first supercooled 0·5°, the temperature of the ether mantle brought to 0·1° below its freezing-point, and finally the separation of ice induced. The freezing-point of the solvent is determined in exactly the same way, both before and after that of the solution. The influence of the cooling-bath is entirely eliminated when its temperature is such that the convergence temperature of the solution coincides with its freezing-point. For the author's apparatus it is found experimentally that the convergence temperature is 0·1° higher than the temperature of the ether when the stirrer is making 5 revolutions per second. The difference of temperature is due to the friction of the stirrer. When the freezing occurs below the convergence temperature (as is usual in the older methods) ice often separates from pure water as a solid mantle, whilst from solutions it usually separates in small crystals. In the first case the apparent freezing-point is higher, in the second lower than the true freezing-point, and consequently the depression found may be several hundredths of a degree too large. The influence of supercooling is best determined experimentally by making determinations with different degrees of supercooling, from which the true freezing-point is obtained by extrapolation. (See 1898, Abstract No. 130.) Dissolved oxygen and nitrogen depress the freezing-point of water by 0·00083° for each cc. dissolved in 100 cc. of water. After allowing for all errors, the method is accurate to 0·001°. T. E.

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859. *Ionisation and Chemical Composition.* **J. J. Thomson.** (Cambridge Phil. Soc. Proc. 10. pp. 10–14, 1898.)—A current of electricity passing through Röntgenised gas increases with the electromotive force but approaches a finite limit (the "saturation-current"), which is attained when the number of ions used up by the current in one second is equal to the number of ions produced in that time by the rays. Therefore, to compare the ionisation in two gases we have only to compare their saturation-currents *when exposed to rays of the same intensity.* Experimental methods of controlling this criterion, and screening the gas against secondary effects, are described. The saturation-currents are as follows: Air = 1·00; H_2 0·33, N_2 0·89, O_2 1·10, CO_2 1·40, CO 0·86, NO 1·08, N_2O 1·47, C_2N_2 1·05, C_2H_2 1·00; H_2S 6; SO_2 6·4; HCl 8·9; Cl_2 17·4; $NH_3 = 1$ (?) Ammonia was doubtful, as it was found difficult

to dry the gas. With the exception of cyanogen, the gases given follow an additive law, following the factors for atoms [H] 0·165, [N] 0·445, [O] 0·55, [C] 0·3, [S] 5·3, [Cl] 8·7; thus for C_2H_2 the saturation-current is (air being unity) $\{(2\times0{\cdot}3)+(2\times0{\cdot}165)\}=0{\cdot}93$ calculated as against 1·00 observed. The results for CO_2, N_2O, SO_2, and HCl do not differ much from those of Perrin; but for H_2 and NH_3 they are about ten times as great. The existence of this additive law indicates that the ionisation produced by the rays is probably not the separation of one atom from another in the molecule of a gas, but a process occurring in the atom itself.

A. D.

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860. *Spectroscopic Test of Ionisation.* **E. Liveing.** (Cambridge Phil. Soc. Proc. 10. pp. 40–44, 1898.)—While the absorption bands produced by solutions of didymium chloride and nitrate respectively have the same positions, general character, and intensities, so long as the solutions are equivalent and moderately dilute, yet more concentrated equivalent solutions show unequal variations in the intensities of the absorptions, some being stronger with the nitrate and others stronger with the chloride.

Equivalent solutions of the sulphate, nitrate, and chloride give absorptions which are indistinguishable from each other. This is in accordance with the theory which has been worked out by Ostwald, that dilute solutions of salts which have one and the same coloured ion, with various colourless ions, all show the same absorptions.

Comparing the effects of the same thickness of solutions of the various degrees of dilution, we find in the region between λ 522 and λ 365:—

1. That all the bands produced by the dilute solutions are strengthened, in both chloride and nitrate, in the stronger solutions, and also widened, the more diffuse being most widened. The narrow, sharply defined band about λ 427 retains its character, but is nevertheless sensibly widened.

2. The difference between the nitrate and chloride is that the light on the more refrangible side falls away in the spectrum of the chloride, from about λ 420, at a more rapid rate than in the spectrum of the nitrate. It is as if a broad, weak absorption, beginning from the more refrangible part, gradually extended down to the violet region in the chloride but not in the nitrate.

If we accept the theory that the absorptions common to the salts in dilute solutions are due to their common ions, namely, the didymium and other metallic ions, then these broad absorptions, which appear to be added when a stronger solution of the chloride is employed, may be ascribed to the undecomposed chloride, or they may possibly be due to the chlor-ion. But the latter alternative is highly improbable.

Throughout the series the absorption bands which are common to the chloride and nitrate are always, except in the most dilute solutions, a little stronger for the chloride than for the nitrate, the difference being more pronounced for stronger solutions. This may be accounted for by supposing a larger proportion of the chloride to be ionised than of the nitrate.

Generally the observations tend to confirm the theory of Ostwald, but much more extended observations are needed, and some with other salts are already in progress. The effects of temperature will be taken in hand as soon as possible.

It is difficult to see how the ionisation theory of solution can be tested spectroscopically in any other way, at least until we have learnt what the spectroscopic characters of the ions are. It is not possible, with our present knowledge, to predict the properties of ions, except so far as to say that, since the ions differ in their intrinsic energies from the elements of the salts ionised, it is almost certain that they will differ in their properties too.

E. E. F.

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861. *Cause of Dissociative Power of Solvents.* **J. W. Brühl.** (Zeitschr. Phys. Chem. 27. pp. 319–322, 1898.)—The author points out that similar considerations to those he put forward regarding oxygen (Zeitschr. Phys. Chem. 18. p. 514, 1895) will apply to nitrogen as a determinating constituent of compounds as regards high dielectric constants and power of ionising electrolytes; this is so in the case of liquid NH_3 (Cady. Journ. Phys. Chem. 1. 707, 1897. See 1898, Abstract No. 188) the nitrites and nitroparaffins (Dutoit. Compt. Rend. 125–240, 1897, and Bull. Soc. Chim. 19. 321, 1898), and he suggests that such properties may also be looked for in other unsaturated atoms, as sulphur in the mercaptans and organic sulphides, phosphorus in PCl_3, and possibly carbon in the acetylene compounds. B. B. T.

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862. *Galvanic Cells.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 150–153, 1898.)—The author deals with the solution of the zinc in galvanic cells, and with a depolariser of his own. Zinc can dissolve in a solution of sodium chloride under formation of zinc hydrate and generation of hydrogen, even in the absence of oxygen, because all metallic chlorides undergo hydrolytic dissociation in water. The cell contains zinc chloride as $Zn(OH)_2.2HCl$, which takes up more zinc "until the whole of the acid has been converted into insoluble basic salt." He confirms this theory of hydrolysis, which had already been advanced by Kippenberger in 1895, by referring to Tommasi's thermal constants. The hydroxide and acid molecules of the hydrolysed chloride would not be independent of one another, but remain combined, as in the case of the guanidin salts $CN_3H_5.HCl$; they would become separated,

however, when further aqueous molecules intervene. What the closing of the circuit has to do with the phenomena is not explained. The depolariser is chlorate of sodium. Platner's ferri-sulphate cell has an E.M.F. of 1·98 volts; but its internal resistance soon becomes very high. In order to combine the continuous generation of oxygen from the chlorate, which is independent of the current, with depolarisation proper, he fills the interior of his carbon electrode with sodium chlorate, and surrounds the electrode with manganese dioxide. The cells are not described. H. B.

863. *Osmotic Theory of the Galvanic Cell.* **W. Nernst** and **E. Bose.** (Zeitschr. Elektrochem. 5. pp. 233–235, 1898.)—According to the above theory the potential difference between a metal and a solution depends on the concentration of the metallic ions in the solution. Two mercury electrodes immersed, the one in normal sulphuric acid saturated with mercurous sulphate, the other in normal sulphuric acid alone, show very little difference of potential. When, however, by means of two secondary platinum electrodes, the minute quantity of mercury contained in the acid in contact with the second electrode is removed by electrolysis, a difference of potential of as much as 0·443 volt is obtained. With silver electrodes in 0·01 normal hydrochloric acid, the acid surrounding one of them being saturated with silver chloride, a difference of potential of 0·423 volt is similarly obtained. When the two electrodes are connected through 100,000 ohms, the potential difference immediately falls, owing to the extreme readiness with which the electrode in contact with the practically metal-free solution is polarised. T. E.

864. *Electrodes of the Third Kind.* **R. Luther.** (Zeitschr. Phys. Chem. 27. pp. 364–366, 1898.)—These are electrodes reversible with respect to a metal which decomposes water. For example, a lead plate immersed in a solution of a calcium salt, saturated with both calcium sulphate and lead sulphate. The P.D. between lead and solution depends on the concentration of the lead ions; this depends on the concentration of the SO_4 ions, which in its turn is dependent on the concentration of the calcium ions. This last, therefore, determines the P.D. between the lead and the solution, and the electrode behaves as though it were a peculiar metallic modification of calcium with a special solution pressure. The choice of materials for electrodes of this kind is somewhat limited, owing to the necessity of excluding secondary chemical reactions between them. T. E.

865. *Carbon in Electrolytic Iron.* **L. Houllevigue.** (Journ. de Physique, 7. pp. 708–709, 1898.)—Electrolytic iron is generally considered the purest that can be obtained; it is, however, far from being so. Besides the large quantities of hydrogen (100 to 150 times its volume) found in it, there are numerous other impurities. The author considers the important one, carbon, and gives the result of experiments in which the soluble electrode consisted of a strip of steel with 0·4 per cent. of carbon, which was placed in a bath of chlorides of iron and ammonium. Heated to 900°, and tempered above 630°, this specimen of steel is composed of carbon dissolved in iron, but not combined; whilst the same steel, cooled slowly, is composed of pure iron and combined carbon. When the steel electrode was so treated as to be of the first class, electrolytic iron extremely poor in carbon was obtained (0·017 per cent. at the most). On the other hand, an anode of steel cooled slowly after being heated to 900° furnished an iron comparatively rich in carbon (from 0·033 to 0·035 per cent.).

Thus electrolysis appears to affect in a different way tempered steel and steel that is cooled slowly. Carbon dissolved in steel is not carried along with the current; it remains as a muddy deposit at the surface of the anode. Combined carbon, on the contrary, is carried along with the iron in the direction of the current. Combined carbon seems to constitute a complex ion, which is carried all-of-a-piece on to the kathode. J. J. S.

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866. *Electrolytic Production of Nitrobenzene.* **C. Schall** and **R. Klein.** (Zeitschr. Elektrochem. 5. pp. 256–259, 1898.)—Fused ortho-nitrobenzoic acid alone is but a feeble conductor of electricity, but when soda is dissolved in it it conducts readily. In the experiments recorded such a solution was electrolysed at a temperature of 160°–200° C. in a special apparatus described in the text, whereby gas was produced at both electrodes, and the solution became dark in colour, and emitted a smell of nitrobenzene. A solution of 6·4 grm. of soda in 50 grm. of the nitro-acid, treated with a current of 0·8–1·0 ampere from 9 chromic acid or 6 Bunsen elements in series, yielded as a distillate about 1 cc. of nitrobenzene in the space of one or two hours. Carbon dioxide was identified as being produced at the anode. But the action cannot be due to the union of two anions with separation of carbon dioxide, as in this case orthodinitrodiphenyl would result, and not nitrobenzene. W. G. M.

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867. *Electrolytic Preparation of Dithio-disulphides.* **C. Schall** and **S. Kraszler.** (Zeitschr. Elektrochem. 5. pp. 225–226, 1898.)—The authors refer to a previous paper (Zeits. f. Elektrochemie, iii. p. 83) in which the action of the electric current upon

bodies of the general formula RCSSM is dealt with. These appear to split up under the action of the current according to the following equation:—

$$2\ RCSSM = 2\ RCSS + 2\ M = (RCS)SS(SCR) + 2\ M.$$

The same product is obtained by chemical methods by the action of iodine.

Since the publication of the original paper, further experiments upon organic bodies of this type have shown that the electrolytic method does not always yield the corresponding dithio-disulphide, and the authors have undertaken further work, of which the present paper is the record, to throw light upon these deviations from the general rule. This part of the paper does not admit of useful abstraction. In the course of their work they have obtained a new dithiodisulphide by electrolysis of the ethyl trithio substitution product of potassium carbonate. The new body has the formula $(C_2H_5.SC)S - S(CS.C_2H_5)$.

All the dithio-disulphides are oily liquids incapable of crystallisation. J. B. C. K.

868. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 185–190, 1898.)—This is a continuation of the author's previous historical papers (see 1898, Abstract No. 1185, and 1899, Abstract No. 489), and relates to the reducing action of electrolytic hydrogen upon organic bodies in acid or alkaline solution. W. G. M.

869. *Electro-deposition of Vanadium.* **S. Cowper-Coles.** (Chem. News, 79. pp. 147–148, 1899.)—Brilliant, almost silver-white deposits of metallic vanadium are obtained by dissolving 1·75 parts of vanadic anhydride and 2 parts of caustic soda in 160 parts of water, adding 32 parts of hydrochloric acid, and electrolysing the solution at about 180° F. with a current density of 18 to 20 amperes per square foot, and an E.M.F. of 1·88 volts. With higher or lower current densities, or at low temperatures, reddish-brown oxide is deposited along with the metal. N. L.

870. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 18. pp. 88–91, 1899.)—A summary of recent communications by Neumann, Hollard, and Kaeppel upon methods of electrolytic analysis.

Neumann deals with the electrolytic determination of nickel, and describes experiments in which sulphate solutions containing varying amounts of iron were used as the electrolyte. The method which his experiments lead him to recommend allows the nickel to be determined with a maximum error of 0·5 per cent., due to deposition of iron with the nickel.

The determination of lead in the commercial metals and alloys containing it is the subject of Hollard's paper. The lead is deposited as peroxide at the anode.

Kaeppel deals with the estimation of manganese. He has found that the addition of acetone to the electrolyte renders the deposition of the manganese as manganese-peroxide much more satisfactory. In spite of this improvement, it is not yet possible to determine by electrolysis the amount of manganese in solutions containing excess of iron. The determination of the iron in presence of manganese can, however, be carried out by use of sulphate solutions containing sodium pyrophosphate, and details of an improved method of carrying out this electrolysis are given.

The references to the original papers are given in this article, and for full details these should be consulted. J. B. C. K.

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871. *Electrolytic Estimation of Cadmium.* **E. Rimbach.** (Zeitschr. Analyt. Chemie, 5. pp. 284–290, 1898.)—Large experience of Beilstein and Jawein's electrolytic method of estimating cadmium has convinced the author of the convenience and accuracy of the process, notwithstanding the objections which have been raised to it. The best results are obtained by adding about 3 grammes of potassium cyanide to the neutralised solution of the chloride or sulphate of the metal occupying 150–200 cc., and electrolysing for 12–16 hours at the ordinary temperature with an E.M.F. of 3·0–3·3 volts, and a kathode current density of 0·02–0·04 ampere per square decimeter. The metal is thus obtained as a firm, coherent, silver-white deposit, and the test analyses quoted are very satisfactory. Contrary to Thomälen's experience, excellent results were obtained by the use of from 3 to 5 Meidinger cells instead of a storage battery. Cadmium may, by this process, be estimated in the presence of aluminium, tin, copper, &c., but if the metals are present as nitrates it is necessary to increase the kathode current density to about 0·4 ampere per square decimeter in order to obtain complete precipitation. If magnesium is present, sufficient ammonium chloride must be added to keep this metal in solution. N. L.

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872. *Electro-metallurgical Industries of England.* **J. B. C. Kershaw.** (Electricity, N.Y., 14. pp. 344–345, 1898.)—This article is a continuation of that previously noticed. (See 1898, Abstract No. 962.) The works of the British Aluminium Company at Foyers, and of Messrs. Bolton & Sons, at Froghall and Widnes, are dealt with.

At Foyers, aluminium has been produced since June, 1896; 3,500 H.P. is stated to be utilised between the two manufactures carried on there—aluminium and calcium carbide. The power is generated by five turbines, working under 350 feet head o water, each generating 750 H.P. The armatures of the dynamos are keyed on to the same vertical shaft, and weigh fourteen tons. Three more sets of generating machinery are to be installed. The total power available at Foyers will then be 6,000 H.P. Details of the capital and profits of this Company are given.

At Froghall and Widnes, Messrs. Bolton & Sons carry on the electrolytic refining of copper. At Froghall, four Corliss valve triple expansion condensing engines are in use. These drive eight Elwell-Parker continuous current dynamos, each 75 kw. Rope gearing is used. At Widnes two Galloway slow-speed engines drive by belts four dynamos similar in design and size to those at Froghall. The total production capacity of the two works is about 12,000 tons copper per annum.

Views showing the generating machinery at Foyers and at Widnes, and the copper-depositing vats at the latter place, are given. AUTHOR.

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873. *Electrolytic Vats.* **H. Becker.** (Ind. Électrochim. 2. pp. 57–58, 67–68, 73–74, 89–91, 1898.)—A serial, giving brief abstracts of the more important patents.

In No. 8 (pp. 57–58) the patents of Watt (1851), Wastchuk and Glukoff (1880), Hoepfner (1884), Philipps (1885), Greenwood (1888–1890–1891), Richardson and Holland (1890), and of Richardson (1891), are briefly described.

No. 9 (pp. 67–68) contains abstracts of the following patents: —Le Sueur (1891), Kellner (1891), Cutten (German P., No. 69,461), and Blackman (German P., No. 69,087).

In No. 10 (pp. 73–74) the patents of Andreoli (German P., No. 75,033), Faure (German P., No. 70,727), the Union Chemical Company (1893), Blackmore (?), Gorgensen (1894), Drake (1894), Roberts (1892 and 1894), Lucius and Bruning (French P., 1894), Gall and Montlaur (French P., No. 240,697), Outhenin Chalandre et Cie (German P., No. 73,964), Hulin (German P., No. 81,793), Bain (German P., No. 84,549), Blackman (U.S.A. Patents 541,146 and 541,147), and Straub (Germar P., No. 73,662), are dealt with.

All the above electrolysers are designed for the production o soda and chlorine, without any preliminary separation of th alkali metal at the kathode.

In No. 12 (pp. 89–91) electrolysers designed for the production of carbonates or other compounds of the alkali metals are described. These include those of Hargreaves-Bird (carbonates), Hermite and Dubosc (aluminates), and of Parker and Robinson (oleates and stearates).

The following electrolysers in which the sodium is separated in the form of an amalgam are also briefly described in this number:—

Rolf (1882), Hermite (1888), Hermite and Dubosc (German P., No. 67,851), Atkins and Applegarth (German P., No. 64,409), and Castner (1892).

Except in the case of the Castner and the Hargreaves-Bird electrolysers, no details of the yield or efficiency of the various forms of cells are given. In these two instances, the figures given by the inventors in 1894 and 1895 respectively are quoted.

J. B. C. K.

874. *Efficiency of Electrolytic Vats.* **C. F. Burgess.** (Elect. World, 32. pp. 686–688, 1898.)—The author gives expressions for the energy efficiency (ratio of change in chemical energy to electrical energy), and also for the quantity efficiency of an electrolytic vat. There is also the electrical efficiency, or the ratio of the E.M.F. of polarisation to the applied pressure. Methods are described for the measurement of polarisation of vats, that in use at the University of Wisconsin being given in detail. It is advisable to measure the polarisation at both anode and kathode, by means of a normal electrode, so that losses may be located. Curves are reproduced showing the variation of polarisation with current. W. R. C.

875. *Electro-deposition of Gold.* **E. Andreoli.** (Électricien, 16. pp. 268–270, 304–306, and 340–343, 1898.)—Articles upon the electro-deposition of gold in the Transvaal. EDITOR.

876. *Memmo Carbide Furnaces.* (Zeitschr. Elektrochem. 5. pp. 197–200, 1898.)—Memmo's two furnaces (English Patents 24,077 and 14,022 of 1897) are described at length. In the former, which is said to possess many faults, the carbon rods forming one pole pass vertically into a melting-chamber with graphite walls and bottom, the latter being hollowed like the hearth of a reverberatory furnace to facilitate the removal of the carbide formed, and being, moreover, itself movable. The charge is fed in through a hopper at one side; the evolved gases (carbon monoxide and hydrogen) may be recovered by means of a stopcock attached to a closed chamber constructed of sheet iron, which forms the upper part of the furnace, and through which the carbon-rod electrodes are passed, gas-tight, by means of a stuffing-box. In the other furnace the heating chamber is of cast iron lined with refractory material, the bottom consisting of a graphite plate in an iron frame capable of being moved up and down, piston-like, in a steel tube. The carbon-rod electrodes are arranged

horizontally, or nearly so, and pass through the side walls of the heating chamber, the number of rods depending upon the character of the current used ; for direct or single-phase alternating currents two rods, for two-phase three, and for three-phase currents four, rods being employed. The ends of the rods must be in the centre of the hearth, and each rod is therefore passed air-tight through an iron sleeve, and its position is made adjustable by means of screw-gear. Above the heating chamber, and connected with it by a narrow neck, is an upper compartment of iron lined with refractory material and provided with an air-tight lid ; this serves to contain the charge, which is fed by means of a screw to the space above the arc. The water-gas formed by the reaction of the calcium hydroxide and carbon is collected, and may be burnt with air and so used to pre-heat the charge. The furnace may be used if necessary for heating by incandescence instead of by the arc, in which case thin rods of carbon or of some badly conducting material are placed between the carbon electrodes, and are thus raised to incandescence by the current. W. G. M.

877. *Enclosed Electric Furnace.* (West. Electn. 24. p. 52, 1899.)—This is an account of a novel calcium carbide furnace with which an experiment was conducted at the Armour Institute of Technology, Chicago. The novelty consists in employing a heavy carbon anode, pierced with a hole about 1½ in. square, through which the pulverised mixture of 60 per cent. lime and 40 per cent. coke was fed on to a sort of hollow carbon hearth, which formed the other electrode.

It is proposed to use this form of enclosed furnace to take advantage of the increased temperature and to enable the operation to be carried on continuously, so long as the carbons last, which is estimated at about a week. So far, however, the tests have not been in any way conclusive, and, chiefly owing to difficulties in feeding, the longest trial made appears to have been only forty minutes.

The American Carbide Co. propose to erect a plant at Maquoketa, Ia., with an initial capacity of 1,000 H.P.

J. L. F. V.

878. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 18. pp. 15–20, 1899.)—An illustrated description of the Wood, Memmo, Roberts, Crees, Durban, and Gore, Siemens, and Maxim electric furnaces. W. G. R.

879. *Electric Furnaces.* **F. J. Patten.** (Elect. World, 32. pp. 413–416, 1898.)—A description of various furnaces.

EDITOR.

GENERAL ELECTRICAL ENGINEERING.

880. *Curve of Accumulator Charge.* **P. Girault.** (Ind. Élect. 7. pp. 453–455, 1898.)—The equation of the current time curve of an accumulator is shown to be of the form

$$i = \mathrm{A} + \mathrm{B}\varepsilon^{-mt}$$

if it be charged at constant potential. A, B, and m are derived analytically, and the result compared with a couple of experiments on a Blot cell. M. O'G.

881. *Faure-Sellon-Volckmar Motor Car Accumulators.* (Ind. Élect. 7. pp. 523–524, 1898.)—The plates are of pure lead with very small perforations. The lightest type (3.6 watts per kilogram of complete cell) has a capacity of 31·3 watt-hours per kilogram. Greater durability is claimed than for the Fulmen type.

M. O'G.

882. *Tests of Traction Accumulators.* (Elect. Rev. 44. pp. 6–8, 1899.)—Particulars of tests to which batteries will be subjected in the course of trials by the Automobile Club of France.

M. O'G.

883. *Pulvis Accumulator.* (Elect. Rev. 44. p. 115, 1899.)—The only novel features in this accumulator are the employment of fine lead powder as the original active material and the use of *ambroïne* (see 1898, Abstract No. 142), a new insulating material composed of fossilised resins, asbestos, and mica, in the construction of the cells. Full details of the dimensions and weights of the various parts are given. The specific capacity and specific energy per pound of total weight are 4·26 ampere hours and 8·3 watt-hours respectively, whilst the specific weight is 124 lb. per kilowatt or 24·82 lb. per kilowatt-hour. N. L.

884. *Accumulator Construction.* **D. Fitz-Gerald.** (Elect. Engin. 21. pp. 747–749, 1898, and 23. pp. 9–10, 42–43, 71–73, 134–135, 167–168, 277–278, 366–367, 463–464, 531–532, 1899.)—Continuation of articles on this subject. EDITOR.

885. *Hellesen Dry Battery.* (Elect. Rev. 44. pp. 44–45, 1899.)—Curves of discharge are given, determined by the Reichsanstalt.

W. R. C.

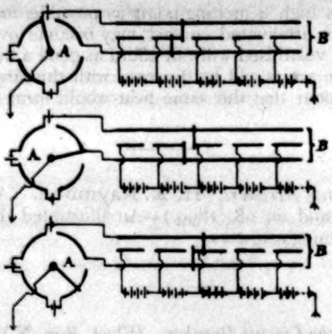
886. *Arcs and Non-arcing Metals.* **G. T. Hanchett.** (Amer. Electn. 11. pp. 16–17, 1899.)—If the vaporised substance in the arc is the greater portion of the resistance of the circuit the arc will extinguish. A non-arcing metal must therefore have very little resistance, and the break in the circuit must occur where there is a large plane surface of contact. A non-arcing metal should have as high a melting-point as possible, for in this way, even though an attenuated contact may become overheated, the amount that is volatilised will not afford as good a nucleus for the formation of an arc as will be the case with the larger volume of conducting vapour that the same heat would form from a more fusible metal. W. G. R.

887. *Lightning Arresters.* **H. E. Raymond.** (Amer. Electn. 11. pp. 15–16 and 66–68, 1899.)—An illustrated description of American lightning arresters. W. G. R.

888. *La Roche Circuit Breaker.* (Elect. Rev. N.Y. 33. p. 282, 1898.)—This is a description of a circuit breaker made by F. A. La Roche & Co., of New York, and is guaranteed to break 2,000 volt circuits without arcing at the clips. By means of a milled-head screw the circuit breaker can be adjusted to open at any point within its guaranteed high and low ampere ratings. The instruments are carefully calibrated, and are made in sizes from 15 to 500 amperes. W. G. R.

889. *Automatic Mercury Switch.* (Elekt. Runds. 16. pp. 94–95, 1898.)—A description is given of the mercury switch recently patented by Bastians. The switch is an overload switch, and in its normal position contact is maintained between the two terminals, which are mounted at the top of two vertical tubes of insulating material, by a column of mercury filling the tubes. The mercury is maintained at its proper level by a plunger, which is kept pressed down in a cylinder communicating with the two tubes, and which, by displacing the mercury, causes it to rise to the required level. The plunger is maintained in its proper position by a locking device. When the current exceeds the safe limit, the locking device is released by an electromagnet, the plunger is forced up by the mercury, which flows back into the cylinder, receding from the terminals and so breaking the circuit. Arcing is prevented by one or more glass beads, which float on the surface of the mercury in the tubes. A. H.

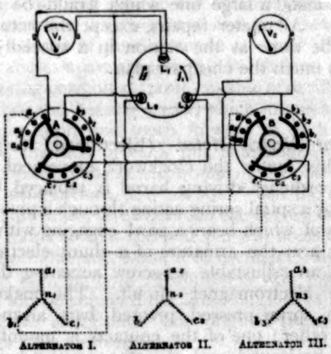
890. *Heath and Field Accumulator - Regulating Apparatus.* (Elect. Engin. 23. pp. 40–42, 1899.)—This is an arrangement chiefly designed for enabling the number of cables required for connecting the regulating-cells in the accumulator-room to the switchboard to be reduced to less than half that heretofore required. It comprises two switches A, B, having their arms geared together so that the arm of A makes, say five revolutions, for each revolution of the arms of B. The connections and operation of the apparatus will be obvious from the accompanying diagrams showing successive positions of the switch arms, the fixed contacts of the switch B being developed in order to simplify the connections. Some modifications are also described. C. K. F.



891. *Three-motor Electric Travelling Crane.* (Engineer, 87. p. 8, 1899.)—Vaughan & Sons, Manchester, have already supplied to a number of works three-motor overhead electric travellers; they have just completed one capable of lifting 50 tons. The paper describes the main features of a 20-ton traveller of similar type; this crane has a span of 45 feet, a longitudinal travel of 300 feet per minute, and a cross travel of 180 feet per minute. The three reversing switches, which are of the liquid resistance type, are contained in the cage, and are so arranged that the three movements of the traveller may be controlled either separately or simultaneously. Any risk through carelessness is removed by means of a powerful automatic brake. The brake lever is held up by an electromagnet as long as current is switched on to the motor. The act of switching off immediately automatically applies the brake. A 30 H.P. "Castle" dynamo, worked from the ordinary line of shafting, generates sufficient current for working the travelling crane, together with shop motors and arc lamps. A. S.

892. *Synchroniser for Three-Phase Plant.* (Elect. Rev. 44. pp. 318–319, 1899.)—The following ingenious arrangement, shown in the accompanying figure and due to Siemens and Halske, is used for synchronising three-phase generators.

A and B are two switches, each provided with as many arms (3) as there are generators, and a corresponding number of contacts. Corresponding terminals of the generators and switch contacts are indicated by the same letters. By means of the switch B, the terminals of any incoming machine may be connected to the bus bars through the synchronising lamps L_1 L_2 L_3. If the connections of the switch contacts were symmetrical, then the three lamps would at any instant be incandesced to the same extent. It will be noticed, however, that the connections are not symmetrical, the long segment contact corresponding to b_1 b_2 b_3 in switch A being in connection with the segment corresponding to c_1 c_2 c_3 in switch B. The result is that when the *a* circuits of two machines happen to be in phase, so that—with the switches A and B in their proper positions—the lamp L_1 is extinguished, the *b* circuit of one machine is connected to *c* circuit of the other, and *vice versâ*, the lamps L_2 and L_3 being incandesced. If the machines are not running synchronously, the lamps will be extinguished consecutively, the extinction travelling round the triangle one way or the other, according as the incoming machine is running below or above the speed of synchronism. The device therefore at once indicates whether it is necessary to increase or diminish the speed of the incoming machine. The main switch is closed at the instant when L_1 is dark, and when the rate at which the extinction travels round the triangle shows that the machines are running very nearly in synchronism. The voltmeters V_1 and V_2 are provided for greater sensitiveness. A. H.



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893. *Manufacture of Carbons.* **F. Jehl.** (Electrician, 42. pp. 217–219, and 301–303, 1898, and 379–380, 439–440, 612–614, 648–649, 789–790, 855–856, and 890–892, 1899.)—Continuation of articles on this subject. EDITOR.

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894. *"Fortis" Material for High Tension Lines.* **J. Reyval.** (Écl. Électr. 17. pp. 351–356, 1898.)—Illustrated account of Fortis insulator and other material. EDITOR.

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895. *Meter Practice.* **L. C. Reed.** (Amer. Electn. 11. pp. 33–35, 1899.) — A meter works for the most part at 5 to 20 per cent. of its rated capacity. It is better to risk burning up a meter than to instal a large one which would be inaccurate on the usual load. All meter repairs, except the actual making of parts, should be done at the station in a specially fitted repair shop. This is much the cheapest plan. E. H. C.-H.

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896. *Richard Electric Meter.* (Electricien, 16. pp. 267–268, 1898.) — In this meter the clockwork movement is driven as follows: The ordinary driving barrel is replaced by a ratchet-wheel turned by a spiral spring acting through a pivoted T-shaped lever, one arm of which bears a pawl engaging with the ratchet-wheel, another arm the armature of a shunt electromagnet, and the third arm an adjustable set-screw actuating the make-and-break of the electromagnet circuit. The make-and-break comprises two spring-pressed pivoted bars arranged at right angles to each other; one of the contacts is mounted on one of these bars (the horizontal one), the other contact being stationary and arranged opposite to it. The horizontal bar bearing the contact is arranged to be held away from the fixed contact by resting on the end of the other or vertical bar whilst the driving spring is extended and the pawl is turning the ratchet-wheel, but when the spring has drawn the pawl to the end of its travel, *e.g.*, an angle corresponding to one tooth, the set-screw on the third arm of the T-shaped lever pushes the vertical bar from beneath the horizontal bar, which descends and allows the circuit to be completed through the electromagnet. The armature is then attracted, the driving spring extended and, by means of a second adjustable set-screw on the T-shaped lever, the horizontal bar is raised and the circuit through the electromagnet interrupted, the horizontal bar being again retained in its raised position by the vertical bar which moves beneath it under the action of its spring. These motions are reproduced every twenty seconds.
C. K. F.

897. *Cauderay Multiple Electric Meter.* **M. Aliamet.** (Électricien, 16. pp. 395–400, 1898; British Patent, No. 7,877 of 1897.)—This meter comprises a clock the hands of which integrate the hours and decimals thereof. The movement of the wheels of this clock is produced by a balance-wheel controlled by a special spring, the motion of which is maintained electrically. The integrator, actuated periodically by the clock, moves proportionately to the number of circuits supplied with current at the station, the motion of each taking place independently, *e.g.*, if the lamps at the station are divided into two circuits, the integrator will move twice as fast when the two circuits are supplied with current, as when only one is supplied. The balance-wheel arbor bears an armature which is intermittently attracted by two oppositely arranged electromagnets, the circuits of which are made and broken by a spring-controlled pivoted finger engaging a notched cam on the balance-wheel arbor. The said arbor, by means of a spring pawl and a ratchet-wheel, drives a shaft having a series of pins arranged at equal distances apart along at equal angles apart around it. Parallel to this pin-shaft is mounted a spring-controlled frame capable of oscillating through a limited distance and bearing a pawl which moves a ratchet-wheel on the integrator train one tooth forward at each oscillation of the frame. By the side of each pin, is arranged one end of a pivoted lever controlled by an electromagnet in one of the circuits to be supplied with current, and adapted, when the electromagnet is energised, to move the lever between the corresponding pin and the oscillating frame so that the said pin will press the end of the lever against the frame and cause it to oscillate. By these means it will be seen that, in each revolution of the pin-shaft, the integrating train will be actuated the same number of times as there are electromagnets energised. The original paper is illustrated by a number of clear drawings. C. K. F.

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898. *Control of Distant Mechanism by Electricity.* (Elect. Rev. N.Y., 33, p. 298, pp. 305–308, p. 312, 1898.)—These articles give the full text of a recent patent in which Tesla sets forth his proposed method of steering and controlling ships by the use either of Hertz waves or of earth conduction. The coherer-principle is the basis of most of the devices. Coherers, or their equivalents, govern the various relay-circuits which control the mechanism of the propelling and steering gear. R. A.

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899. *Electrical Survey in New York City.* **A. A. Knudson.** (Amer. Instit. Elect. Engin. 15. pp. 653–672, 1898.)—Details are given, with plans and tables, of an electrical survey made in New York City, U.S.A. It is shown that no appreciable leakage occurred from the open conduit tramway, in which an insulated return is used; but a steady potential difference of $\frac{1}{30}$ to $\frac{1}{10}$ volt between rails and earth was traced to the electric lighting systems

and a variable P.D. to an overhead trolley line. The tram rails were in general positive to water and gas-pipes, the P.D. ranging from $\frac{1}{3}$ to 2 volts. At a terminus of the trolley line this P.D. increased to 10 volts, and here the rails were excessively corroded. The Brooklyn suspension bridge was generally 2 to 3 volts positive to earth: the probable effect of the resulting current upon the cables and anchor-plates is discussed, but not considered important. It is shown, however, that a very small P.D. may cause serious injury to pipes, &c., and that cast iron is by no means exempt. A. H. A.

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900. *Utilising Capacity of Cables.* **H. Andriessen.** (Elect. Engin. 23. pp. 10–11, 1899.)—To obviate the lag of current on lighting circuits with inductive loads, concentric cables are cross-connected at the junction points: the inner to the outer, and the outer to the inner wire. The effect of this is to increase the capacity between the wires. In a given example this amounted to 65 per cent. The potential difference between each conductor and the earth is equal to half the E.M.F. of the dynamos. M. O'G.

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901. *Hot Pressing of Cloth.* **C. Mouchel.** (Electricien, 17. pp. 58–59, 1899.)—German silver wires are imbedded in asbestos laid up between two sheets of card (2 to 4 millimetres thick) the two terminals of the wire being brought to opposite corners of the cards under a strengthening metallic corner. The whole is then used between the folds of the cloth to be pressed, electrical contact being made with the projecting corners by means of clips. Perfect control of temperature, economy of coal, and low first cost are claimed. The system is due to Chedville. M. O'G.

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902. *Electric Vehicles and their Relation to Central Stations.* **H. M. Maxim.** (Elect. World, 33. pp. 116–117, 1899.)—In this article the author urges suppliers of current to give every facility for charging accumulators from their mains as by so doing they will forward the more general adoption of motor vehicles and cultivate what will eventually become an important addition to their customers. For the information of supply companies and accumulator manufacturers it is stated that at present accumulators for vehicles should show a capacity of from 3·5 to 4 ampere hours per pound of cell complete with lugs, jar, &c., at a discharge rate of not less that 1·3 amperes per pound of complete cell. It must be possible to increase this rate to 4 or 5 amperes per pound of cell for short periods, without injury, and to effect complete charge in three hours, or thereabouts. In France several firms are engaged in the business of letting out or caring for vehicles fitted with high capacity batteries, for which there is a great demand. Motor cars should be of great use for such purposes as parcels' delivery, &c. W. G. R.

903. *Parvillée Electric Heating Apparatus.* **J. Reyval.** (Écl. Électr., 18. pp. 138–143, 1899; U.S. Pat., No. 658,450.)—In this apparatus the heating resistance is formed of a substance capable of being heated in the open air. This substance is made by adding to a metallic powder (preferably nickel) a ceramic product (*e.g.*, a mixture of quartz, kaolin, and a flux), grinding the whole together, compressing it in rectangular moulds at a pressure of 2,000 kilos. per sq. cm., and then drying and baking it in a furnace at a temperature of 1,350° C. A plate 5 cm. × 3 cm. × 1 cm. has a resistance of 100 ohms, and will stand heating to a bright red heat for 1,400 hours without deterioration. These resistances are held in copper clips mounted on flexible strips, so as to permit expansion. The selling price of a resistance absorbing 5 A. at 110 V. will not exceed 3f. Several forms of stove employing these resistances are illustrated in the original paper. C. K. F.

904. *Electric Power in Mining.* **J. McGhie.** (Cassier, 15. pp. 37–48, 1898.)—This is a well-illustrated article on electric mining machinery, chiefly American. R. B. R.

905. *Electrically Operated Drawbridge.* **W. Kidde.** (Electricity, N.Y. 15. p. 295, 1898.)—Since February, 1898, a 450-ton drawbridge over the Passaic River at Newark, N.Y., has been successfully operated electrically. The contractors were required to furnish power (from a 500 volt direct circuit) which would open or close the bridge in thirty seconds, this power not to be available until the wedges and locking device had been withdrawn; also the wedging and closing devices must be automatically cut off, so that they could not be used till the bridge is closed. These conditions have been successfully met, and the bridge operated by three unskilled men on their regular trips. Two cables are carried under the bed of the river up through the centre pin of the bridge into a contact commutator under the roadway. The commutator has two parts, the lower consisting of a copper ring and central disc attached to, but insulated from, the stationary centre bridge pin. Over this is the heavy circular part which moves with the draw and carries on a diameter three insulated contact shoes, two of which are respectively held in contact with the ring and disc on the stationary part, and thus establish a lead and return to the motor-room above. The third shoe only touches the lower ring when the bridge is closed, and breaks contact by means of quick acting springs directly the bridge begins to open; the circuit through this shoe and the centre disc drives the motor when operating the wedge shaft. The motor-room contains one motor with extended shaft to carry several clutches and gears. The first is the spur-wheel driving the line shaft which operates the bridge, and is mounted on a friction clutch. Another clutch is attached

by a sprocket-wheel and chain to the shaft for the locking devices and wedges. These two clutches are worked alternatively by a common lever, which also makes the requisite electrical connections. In mid-position neither clutch is in use.

The position of the wedges is indicated on a disc by a mechanism which also automatically interposes a latch bar in the arc of the clutch lever, so that the bridge cannot be turned until the wedges have been withdrawn. An air-pump, connected to the motor-shaft by iron link belting, maintains 40 lb. pressure in a receiver for a signal whistle. The speed and direction of rotation of the motor are governed by a reversible controller, which regulates the speed with the different loads due to operating pump, wedges, and bridge. This controller and the clutch-lever are worked from a position overlooking the river. The drawbridge structure is 720 feet long, while the draw proper is 227 feet in length and 67 feet wide. The moving span weighs 450 tons. The author suggests that the score of bridges close to one another over the Harlem River in N.Y. City should be electrically operated from one central plant radiating power which would precede a ship in its passage through the successive draws. E. H. C.-H.

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906. *Electricity in Open Hearth Steel Works.* (Eng. News, 40. pp. 194–197, 1898.)—The author describes how various mills are operated with electrical tables and cranes. For example, a reversal mill handles 24″ I–beams, and is served by a single attendant by a combined hydraulic and Ward-Leonard electrical table. The advantage of the rolling mill equipped with these tables was found to be that the metal could be delivered at a speed of 1,000 feet per minute, and regularly rolled into 150 feet lengths or longer. The plant is described in some detail. M. O'G.

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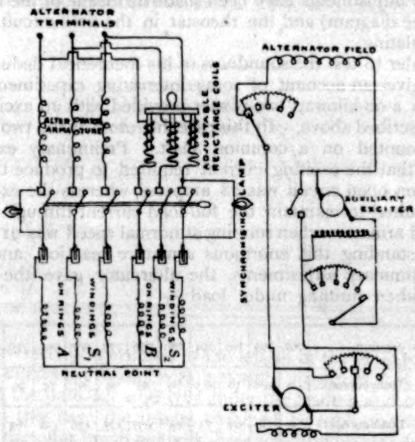
907. *Electric Lifts for New Brighton Eiffel Tower.* (Engineer, 87. pp. 3–5, 1899.)—The whole of the lifting plant at the New Brighton Tower is operated by electric motors, the contractors of which are Easton, Anderson, and Goolden. Two lifts for passengers and one for goods run from the base to a platform 80 feet high. There are two lifts in the spire conveying passengers from the 80 feet level to the 384 feet level. The galleries above the 384 feet level are reached by a staircase. In these lifts the winding drum is done away with, its place being taken by a simple eight-grooved rope pulley and a crossover pulley. The eight-grooved pulley is driven by means of a wheel and worm enclosed in a cast iron casing with suitable thrust block. The motor shaft carries a brake drum, acted upon by a magnetic brake which automatically holds the gear, except when the motor magnets are energised and lifting or lowering is taking place. The balance weights have a stroke of one-fourth the passenger cages. The arrangement of the guide pulleys is described, and the whole arrangement of the gear illustrated by numerous drawings. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

908. *Compounding Alternators.* **M. Leblanc.** (Écl. Électr. 17. pp. 425–432, 473–482, 509–512, and 547–551, 1898.)—The author first describes the arrangement referred to in Abstract No. 620 (1899), and then proceeds to further develop the theory. The result arrived at indicates that there should be no difficulty in constructing the exciter in such a manner as to secure absolute constancy of P.D. between the alternator terminals with varying load. The question of parallel running is next discussed, and the author shows that by the use of his exciter an alternator with enormous armature reaction may still be expected to synchronise better than machines of ordinary construction. Since the exciter has to run synchronously with the alternator, the simplest plan is to mount the rotors of the two machines on the same shaft, and provide the fields with the same number of poles. This method is not, however, feasible in the case of very large slow-speed machines, or where it is desired to provide previously constructed machines with the new form of exciter. Reduction gearing might be used; but the following method would probably be more convenient. In addition to the winding, which is designed to counteract armature reaction, and which is traversed by the armature current of the exciter, another similar winding is provided, but arranged so that when it is traversed by the armature current it gives rise to poles in the field rings which lie between the poles due to the former winding. The field due to this additional winding causes the armature to run in synchronism with the



alternator; the exciter, in fact, forming a combination of a synchronous motor driven by the alternator with a continuous-current dynamo exciting it.

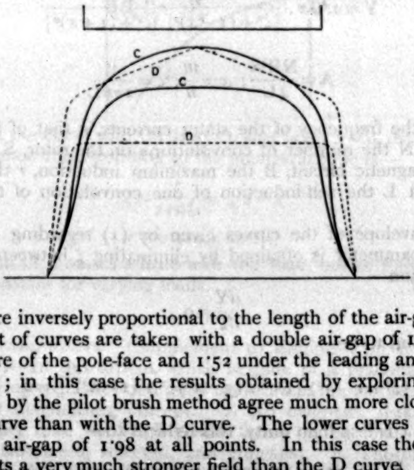
Drawings of a six-pole exciter constructed on this plan for a three-phaser are given, and the arrangement of connections required for starting it is shown in the accompanying sketch. An auxiliary series-wound dynamo is used at starting to excite the alternator, and to run the exciter, which behaves like a continuous-current motor, up to the speed of synchronism. The alternating-current windings of the exciter armature are next connected to the alternator, when the exciter will run as a synchronous motor, and furnish a continuous current. Lastly, the auxiliary dynamo is thrown out of circuit. An alternator provided with such an exciter requires no attention, for when once the necessary preliminary adjustments have been made by means of the impedance coils (see diagram) and the rheostat in the field circuit, it will be self-regulating.

In order to test the soundness of his theoretical deductions, the author gives an account of some interesting experiments carried out with a 60-kilowatt two-phaser provided with an exciter of the form described above. In this case the rotors of the two machines were mounted on a common shaft. Preliminary experiments showed that the exciting current required to produce the normal voltage on open circuit was 28 amperes, whereas the exciting current required to maintain the full-load current through the short-circuited armature when running at normal speed was 91 amperes! Notwithstanding this enormous armature reaction, and without any preliminary adjustments, the alternator gave the following results when running under load :—

Revs. per min.		792	794	789	794	786	770	772	780	792	770	788	762	754
Circuit I.	Idle current	0	74·8	76	76·5	79	80	79	80	79	79	77·5	77·5	74
	Load current	0	0	63	75	85	106	125	120	152	165	192	223	240
Circuit II.	Idle current	0	74·5	75	76·5	79	80	79	80	79	79	77·5	77·5	74
	Load current	0	0	63	73	73	103	122	120	155	155	205	228	250
Terminal P.D.		92	114	116	118	114·5	116·5	118·5	115·5	110·5	114	110	104	96

The total flow of current per cm. length of the rotor circumference amounted in this alternator to 225 amperes, as against 70 in alternators of usual construction ; the output of the machine is therefore about 3·2 times that of an alternator of ordinary design having the same dimensions. Some further experiments were tried, in order to test the behaviour of the machine when running in parallel with others : it was found impossible to throw it out of synchronism. A. H.

909. *Magnetic Flux in Dynamo Air-gaps.* **W. E. Goldsborough.** (Amer. Instit. Elect. Engin. 15. pp. 637–652, 1898.)—If the armature surface is taken as a plane extending indefinitely to right and left, and the pole-piece is a rectangular block with square corners, the number of lines of force which pass between any pair of points on the pole-piece and armature respectively will be inversely proportional to the distance between them measured in air. And the strength of the magnetic field at the surface of the armature at any point will be proportional to the sum of the reciprocals of the distances of that point from all the points on the perimeter of the pole-piece made by a section-plane passing through that point. The figure shows two sets of curves for a bipolar Jenney dynamo; the C curves represent the distribution of flux calculated by the author's method, and the D curves the distribution usually assumed. The ordinates of the D curves are inversely proportional to the length of the air-gap. The upper set of curves are taken with a double air-gap of 1·25 in. at the centre of the pole-face and 1·52 under the leading and trailing pole-tips; in this case the results obtained by exploring the air-gap field by the pilot brush method agree much more closely with the C curve than with the D curve. The lower curves are taken with an air-gap of 1·98 at all points. In this case the C curve represents a very much stronger field than the D curve. The ratio of our mean ordinates of the C curve is 0·899, whereas the ratio for the D curves is 0·699. We see, therefore, that the rate at which the strength of the air-gap field decreases as the length of the air-gap is increased, falls far short of being inversely proportional to the rate of increase in the mean length of the air-gap, supposing that the C curves represent the true condition.



R. B. R.

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910. *Electric Generators.* **H. F. Parshall and H. M. Hobart.** (Engineering, 67. pp. 41–44, 100–101, 374, 475–477,

and 537–540, 1899.)—An illustrated series of articles on various electric generators, and notes on design. EDITOR.

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911. *Alternating-Current Machinery.* **E. J. Houston** and **A. E. Kennelly.** (Elect. World, 32. pp. 627–628, 684–686, 1898, and 33. pp. 175–177, 1899.)—Description of apparatus. EDITOR.

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912. *Monophase Asynchronous Motors.* **G. B. Maffiotti** and **F. Pescetto.** (Ecl. Électr. 18. pp. 145–148, 1899; also Atti della Associazione elettrotechnica Italiana, vol. i. p. 55.)—An expression for the torque Y in a monophase iuduction motor is—

$$Y = 2A\zeta x \,.\, \frac{1 - x^2 - \zeta^2}{\{\zeta^2 + (1 - x)^2\}\,\{\zeta^2 + (1 + x)^2\}} \qquad (1)$$

where

$$A = \frac{NB^2S}{4L};\; x = \frac{m}{n};\; \zeta = \frac{r}{2\pi n L}$$

m being the frequency of the stator currents, n that of the rotor currents, N the number of convolutions on the rotor, S the area of the magnetic circuit, B the maximum induction, r the resistance, and L the self-induction of one convolution of the rotor coils.

The envelope of the curves given by (1) regarding ζ as the variable parameter is obtained by eliminating ζ between (1) and the equation—

$$\frac{dY}{d\zeta} = 0$$

and is found to be—

$$(\zeta^2 + 1 - x^2)\,\{\zeta^4 - 2(3 - x^2)\,\zeta^2 + (1 - x^2)^2\} = 0$$

and since x is less than unity, this reduces to—

$$\zeta^4 - 2(3 - x^2)\,\zeta^2 + (1 - x^2)^2 = 0$$

or—

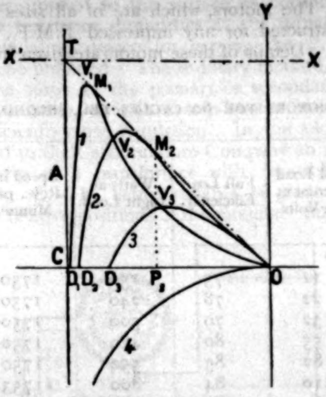
$$\zeta = \sqrt{2 - x^2} - 1 \qquad (2)$$

On substituting this value of ζ in equation (1) the expression becomes—

$$Y = Ax$$

which is a straight line through the origin. This is the locus of the extremities of ordinates representing the maximum values of Y for a given value of the slip when variable resistance is placed in the rotor circuit.

The curves in the figure represent the couple Y as a function of the slip for different values of ζ. If ζ is zero, the curve is represented by the straight lines OT and TC. When the point of contact of the curve with OT is at O, that is for $x=0$, the value of the resistance corresponding to the greatest torque is—



$$\zeta=\frac{r}{2\pi n\mathrm{L}}=\sqrt{2}-1$$

or—

$$r=0{\cdot}414\times 2\pi n\mathrm{L}$$

This value of ζ varies a little with the load, but is found to be almost constant for varying loads. W. G. R.

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913. *Transformers*. (Supplement to Engineer, pp. ii–iv. Nov. 25, 1898.)—In this article, which is quite of a practical nature, the following requisites of a good transformer are emphasised:—

1. Low magnetising current. 2. No magnetic leakage. 3. Low copper loss. 4. High power factor on no load. 5. Iron carefully laminated, selected, and annealed. 6. Thorough ventilation of the iron. 7. Thorough ventilation of the copper. 8. No eddy currents in the copper windings. 9. Low temperature of both iron and coils. 10. Simplicity of construction. 11. Strength in design and construction, so that it may withstand the rough handling to which it will inevitably be subjected. 12. The power to withstand a test pressure between primary and secondary, and between primary and iron, of double that at which the transformer is to be worked.

Illustrations and criticisms are given of Berry, Mordey, Westinghouse, and Kapp transformers. The Walton automatic cut-in switch is also described. W. G. R.

914. *Single-Phase Motors.* (West. Electn. 24. pp 30–32, 1899.) —This is an illustrated description of the monophase induction motors made by the Wagner Electrical Manufacturing Company of St. Louis. The motors, which are of all sizes from 1 to 20 H.P. are constructed for any impressed E.M.F., between 100 and 500 volts. Details of these motors are given in the following tables:—

MOTORS FOR 60 CYCLES PER SECOND.

Horse-Power.	Full Load Current at 104 Volts.	Full Load Efficiency.	Watts at Light Load.	Speed in Revs. per Minute.	Approximate Shipping Weight in lbs.
1	11	75	150	1750	275
2	22	78	240	1750	400
3	32	79	300	1750	550
5	55	80	450	1750	800
7·5	82	83	550	1750	950
10	110	84	800	1753	1050
15	160	86	1000	1150	1600

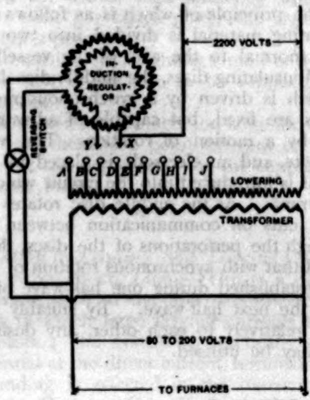
MOTORS FOR 133 CYCLES PER SECOND.

Horse-Power.	Full Load Current at 104 Volts.	Full Load Efficiency.	Watts at Light Load.	Speed in Revs. per Minute.	Approximate Shipping Weight in lbs.
0·75	10	60	135	1950	275
1·5	20	68	200	1950	400
2	25	70	240	1950	550
3·5	47	71	450	1950	800
5	70	73	500	1950	950
7·5	110	75	850	1550	1050
10	135	78	900	1550	1600

W. G. R.

915. *Induction Motor Diagrams.* **C. C. Hawkins.** (Electrician, 42. pp. 467–468, 528–529, and 610–612, 1899.)—This is a series of articles dealing with the theory of induction motors by means of clock diagrams. W. G. R.

916. *Transformer Equipment of Carborundum Company.* **J. S. Peck.** (Elect. World, 33. pp. 16–18, 1899.)—In the manufacture of carborundum it is extremely important to maintain the power supplied to the surface as constant as possible. But since the resistance diminishes as the furnace gets heated up, some regulating device for varying the P.D. across the furnace must be provided. The ordinary method of cutting out or introducing turns in the primary or secondary of the transformer is not suitable, as it is a step-by-step method, and does not give sufficiently close regulation. In the old Westinghouse plant supplied to the Carborundum Company an induction regulator consisting of a transformer with movable circuits was employed, the E.M.F. being capable of gradual variation by changing the relative positions of the circuits. Such an induction regulator is, on account of the large output required, very expensive, and its power-factor is low. In the new plant arrangements have been provided for varying the number of turns in the primary, and the change of E.M.F. in passing from one section of the primary winding to another is rendered continuous by the action of a small induction regulator, whose primary circuit is connected, through a reversing switch, across the secondary terminals of the transformer, while its secondary circuit is in series with the primary mains. The connections are shown in the accompanying sketch, and the action is as follows: Let Y be in connection with J, and let the regulator E.M.F. act in the direction of the main E.M.F. Then the secondary E.M.F. has its highest value. By turning the hand-wheel of the regulator so as to reduce the E.M.F., the following series of operations is carried out: the regulator is rotated, its E.M.F.



Elec. World, N.Y.

gradually diminishing, vanishing, and reappearing with reversal of sign, until the maximum negative value is reached; at this point X is connected to I, Y disconnected from J, the primary of the regulator reversed, Y advanced to H, and X disconnected; and so on. Another important feature of the new plant is the method of cooling the oil in which the transformer and regulator are immersed; this is accomplished by means of a few turns of copper tubing placed just below the surface of the oil, and connected to the water-mains. The cost of the pump, motor, and special cooling tank used in the older plant is thereby saved.

A. H.

917. *Rectification of Alternate Currents.* (Elekt. Runds. 16. pp. 73–74, 1898.)—A description of the device recently patented by C. Pollak, the principle of which is as follows: A cylindrical vessel of insulating material is divided into two compartments by a partition (normal to the axis of the vessel) consisting of three perforated insulating discs, the middle disc being mounted on an axle which is driven by a synchronous motor, while the two outer discs are fixed, but capable of adjustment relatively to each other by a motion of rotation. The vessel is filled with an electrolyte, and an electrode is placed in each compartment. The cell is introduced into the circuit which is to receive the rectified currents. As the middle disc rotates it periodically establishes and cuts off communication between the two compartments through the perforations of the discs, the perforations being so spaced that with synchronous rotation of the disc communication is established during one half-wave of current, and cut off during the next half-wave. By suitably displacing the two fixed discs relatively to each other, any desired portion of the half-wave may be utilised. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

918. *Design of Secondary Circuits in Alternating Plants.* **G. L. Thayer.** (Elect. World, 33. pp. 118–120, 1899.)—In the design of circuits for alternating work, capacity and skin effect may be neglected. Capacity only assumes importance in long distance lines, and the influence of skin effect does not exceed 2 per cent. in 0000 copper at 125 cycles, and less in smaller sizes.

The line of improvement must lie in the direction of better regulation and increased efficiency of distribution. This leads to the general adoption of large transformers to diminish the light load losses and the use of high efficiency lamps. For lamps taking only 3·1 watts per candle-power the regulation must be brought to within 2 per cent.

As regards frequency, for a lighting circuit only 125 periods is suitable, but if motors are also to be supplied it is better to change to 60 cycles.

It is possible to use transformers too large for the most economical results, since there is a point different on every station at which the interest and depreciation on the copper is greater than the saving in core losses. W. G. R.

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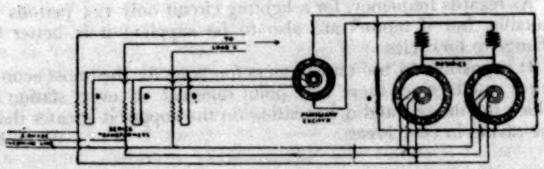
919. *Regulation by Leading and Lagging Currents.* (Journal of Electricity, 7. pp. 28–29, 1899.)—This is a description of the regulating devices used in the Mechanicville-Schenectady transmission plant, in which large lagging currents are produced by induction motors. The system is practically compounded for constant potential at the direct current terminals of the rotaries. The compounding is effected in the transmission line, which consists of three No. 000 wires all mounted on one cross arm. The rotaries at the receiving end are compound wound with a heavy series winding, the ampere turns of the two field windings being so proportioned that on no load the excitation of the shunt winding is sufficient to generate at synchronous speed a back electromotive force sufficient to choke back the impressed alternating current waves. The result is that wattless currents lagging behind the impressed E.M.F. enter the rotary armature and automatically increase the field excitation to a proper value. These lagging currents react upon the self-induction of the line. As the load rises the action of the series coils on the rotaries asserts itself and the wattless lagging currents are diminished.

This arrangement would be sufficient for proper regulation but for the interference of the load taken by some synchronous motors. Any increase of their load increases the ohmic drop in the line without any compensating effect in the wattless currents taken by the rotaries. Any variation also of the phase relations of the synchronous motor load will still further disturb the proper combination of ohmic and induction drop on the line which should be independent of the load. To make the rotaries take currents which shall effect this the following system has been devised :—

The rotary shunt fields, as shown at DD in the figure, are excited from a separate direct current bus bar which is fed with current from the main bus bar through an auxiliary exciter A. This auxiliary exciter serves to raise the voltage across the rotary fields, and is driven by an alternating current synchronous motor of the same number of poles, thus keeping its armature in step with the alternating system. It has no field-exciting winding, but its armature is fitted with three collecting rings into which the alternating current may be introduced from the secondaries of three small series transformers shown at B, the primaries of which are inserted in the lines feeding the synchronous motor C, and any other loads supplied over the same transmission line, with the exception of the rotaries. The armature of the auxiliary exciter is coupled to the synchronous motor at such an angle that the currents introduced from these series transformers, when the load passing through their primaries is of unity power factor, tend to set up a field of force in the magnetic circuit of the auxiliary exciter, and build up a direct current voltage across its brushes ; thus the greater the load on the system, the greater is the boosting action of the machine A, and the greater is the voltage across the field windings, D, of the rotaries. Further, if the load on the system, C, becomes lagging, tending to still further increase the drop on the line, the currents entering the armature of the machine A lag also and excite to a greater extent the magnetic circuit of that machine, causing a greater current in the rotaries which causes the armatures of the rotaries to take leading currents and balance the lagging current of the load C.



In this way the load on the system, C, can vary in magnitude or phase relation by any amount within limits without affecting the voltage relation at the direct current terminals of the rotaries. W. G. R.

920. *Polyphase Distributing Systems.* **T. Marcher.** (Elekt. Runds. 16. pp. 53–56, and 66–68, 1898.)—The paper contains an account of the different systems of arranging transformers and mains for a combined supply of light and power from the same network. Some data regarding the regulating properties of an arrangement patented by the author are given. A. H.

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921. *Electric Transmission in Mining.* **W. B. Esson.** (Instit. Civ. Engin. Proc. 135. pp. 54–74, 1899. Discussion, pp. 75–113, 1899.)—Chiefly a description of a two-phase transmission at the Sheba Company's mines, Barberton, Transvaal. Originally 162 H.P. were required at the mine, 100 H.P. being for a 60-stamp mill. With a 20-stamp mill the working costs for fuel and transport over three miles were £1 12s. 6d. per ton of ore milled, as against 1s. 8d. per ton with the present 60-stamp mill electrically worked at the mine. Two-phase current was chosen as giving the best regulation for lighting. Current is generated at 3,300 volts, and transformed to 100 at the mine. A 30 in. and a 25 in. "Victor" turbine on a 32 feet head give 396 B.H.P. at about 250 r.p.m. "Snow" governors act directly on the turbine gates, but cannot control speed under large fluctuations of load. The Kapp alternators have stationary armatures and rotary field-magnets at 400 r.p.m. excited by a single coil. Frequency 53·3. Switchboards are of polished teak, because of danger in transporting slate: with micanite washers and bushes the insulation is very high. When paralleling alternators the incoming machine is plugged on to the synchronising bars, and when the hot-wire voltmeters indicate approximate synchronism it is thrown into main circuit by closing, through a large choking coil, a path between the synchronising bars and the main bus bars. The choking coil prevents a large rush of current due to phase difference, though it allows sufficient current to pass to pull the new machine into step. The cables are concentric, laid underground to avoid lightning troubles and the drop due to self-induction if they were overhead. The transformers are of single-phase pattern, one on each phase. Efficiency at light loads is of little importance compared with good regulating qualities, efficiency at full load and capability of running continuously at full load. If special two-phase transformers were used, 50 per cent. would have to be kept as spare, whereas 25 per cent. suffices with single-phase. Immersed in resin-oil in cast-iron cases, the insulation failed. Convection currents appeared to circulate any moisture in a finely divided state. The two-phase motors have rotary fields; two of 50 H.P. run at 640 r.p.m., and three of 15 H.P. at 800 r.p.m. The lines of force pass from the stator into the rotor, the field being thus formed of a number of closed magnetic circuits moving circumferentially with a certain velocity. As the field rotates the copper rods of the motor are cut by lines of

force, and currents are induced in them which, tending to stop the rotation of the field, compel the rotor to follow its movement. There must be relative movement or slip between the rotary field and the rotor. In running, the slip adjusts itself so as to allow such currents to be generated in the rotor bars as will give the necessary torque for the particular load on the motor. When fully loaded the slip is about 3 per cent. for the 50 H.P. motors, and 3½ per cent. for the 15 H.P.

At starting the slip is equivalent to the speed of the field, the motor being momentarily at rest. Consequently a large current passes, which in sizes above 10 H.P. is objectionable. In the larger sizes the rotor windings are therefore not short-circuited, but are arranged in three groups, attached star-wise to a common junction, with their free ends brought out to three insulated rings on the shaft. These rings connect with three resistances, also connected star-wise, and provided with a regulating switch working on all three branches simultaneously. Besides preventing excessive current at starting, this resistance increases the torque. The motor will thus start against full running torque without taking more than normal current, or against double torque with double the current. Owing to currents in the rotor weakening the resultant field, when a certain load is reached increased current actually produces a diminished torque, and any further increase of load will bring the motor to rest. The 50 H.P. motors would not work beyond 65 H.P.; their no-load current is 70 amperes per phase at 100 volts, though the true watts are only 1,400. The no-load current is 28 per cent. of the full-load current. But while the power-factor is only 0·1 at no load, at full load it rises to 0·8, and the efficiency is then 92 per cent.

Compressors to be electrically driven should have at least two cylinders with their cranks at right angles. Three-throw single-acting pumps are the most suitable for electric driving.

In the *Discussion* the author stated that the central-bobbin field-magnet had been found unsuitable for induction load, and had given place to radial poles wound separately. **W. H. Preece** said that cables 3 feet underground were as liable to disturbance from lightning as when on poles. **W. E. Ayrton** pointed out that the introduction of resistance at starting reduced the time constant and brought the currents more into phase, so that the large currents in the stator more nearly coincided with the large currents in the rotor. **G. Forbes's** experience with oil insulation in the Niagara transformers had been quite satisfactory. **W. H. Ravenshaw** pointed out the danger in a two-phase motor stopping when hauling up a steep incline. **A. Steiger** discussed turbine governors. In Switzerland they now govern within 4 per cent. when 25 per cent. of full load is taken off, and with 8 per cent. when full load is switched off. **A. Siemens** said the great drawback to three-phase induction motors was that they gave their best efficiency at one particular speed. **G. Kapp** had adopted the two-phase system at Sheba in preference to three-phase, in spite of the latter requiring 25 per cent. less copper in the line, because (1) triple cables were not made twisted but only concentric, which would be too difficult for local jointers, (2) the less the windings overlap (*i.e.*, the fewer the phases) the easier are repairs effected.

Oil insulation is quite satisfactory for transformers, provided proper oil is used with a head over the transformer case. Threads of moisture only occur at the surface of the oil. E. H. C.-H.

922. *Electrical Transmission in Workshops.* (Supplement to Engineer, pp. ix–xiv, November 25, 1898.)—The Broadheath Works of the Linotype Company, near Manchester, are described; details are given of the generating and distributing plant, with curves showing the steady nature of the load. The machine tools, most of which are small, are grouped and belted to lengths of shafting driven by either 5 or 10 H.P. motors. Amongst other details of tests, it is stated that a 2¼ in. shaft, 93 feet long in ten bearings, required 0·42 H.P. at 200 revs. per minute, or 0·042 H.P. per bearing; a similar shaft 130 feet long absorbed 0·052 H.P. per bearing. The power output is about 75 kilowatts; the commercial efficiency of the generating plant is 80 per cent., and the running costs amount to 0·94d. per B.T.U. Lighting and power are supplied from the same plant without inconvenience.

A. H. A.

923. *San Gabriel Los Angeles Transmission Plant.* **G. P. Low.** (Journal of Electricity, 6. pp. 81–103, 1898.)—These works derive their power from the San Gabriel river in California. The intake is situated about six miles above the power house; in summer the river appears to be nearly dry owing to the greater part of the water passing through the loose river-bed and flowing in it. To utilise this water an underground concrete dam has been constructed: this collects the underground water, which is passed into the conduit. The conduit consists principally of concrete lined tunnel and wood pipe, the latter being 48″ internal diameter built up of longitudinal wooden staves bound together with iron hoops, the pipes are laid 10 feet below the hydraulic gradient of the conduit, and are therefore always charged with water.

Four sets of turbines and generators are installed, each set yielding 550 H.P. The turbines are of the Tutthill impulse type, with two bucket-wheels on a horizontal shaft; they run at 430 revs. per min. under a head of 400 feet. The alternators are coupled direct to the turbines, and give two-phase currents at 500 volts.

The current is transformed up to 17,000 volts, and transmitted 23 miles along two three-wire circuits carried by poles; the wires are arranged in two equilateral triangles with 30″ sides. The distribution is very complicated, the station working in parallel with three other sources of supply by means of transformers, motor generators, &c. Current is supplied in Los Angeles by the following systems: (1) Single-phase 2,400 volt service for outlying districts; (2) two-phase 2,400 volt power service; (3) 500 volt direct current power service; (4) 220 volt direct current three-wire service; these different services, combined with the fact that currents reach the sub station from four different sources at varying voltages, &c., make the switchboard arrangements exceedingly interesting.

The article contains a very detailed description of the work, and is fully illustrated. M. G. W.

924. *Plant at Niagara.* **J. E. Woodbridge.** (Elect. World, 33. pp. 3–15, 1899.)—An illustrated description of the plant at Niagara Falls. W. R. C.

925. *Accumulator at San Francisco Edison Station.* **G. P. Low.** (Journal of Electricity, 6. pp. 25–33, 1898.)—The battery consists of two sets of chloride cells, each of about 1½ tons weight, discharging at a maximum rate of 3,500 amperes for one hour. The chief point of interest is the arrangement for cutting the regulating cells in or out as required. The mechanism is placed near the battery-room instead of on the switchboard, to avoid the cost of connections, and is worked by means of a motor. There are special devices for indicating the positions of the regulating switches. W. R. C.

926. *New Union Station: Boston.* (Electricity, N.Y. 16. pp. 19–21, 1899.)—Four separate railways enter Boston from the south. Three of these have been absorbed by the New York, New Haven, and Hartford Railroad Co., which has combined with the fourth, the Boston and Albany Co., to build a new Union Station, replacing the three old ones. Twenty-five acres of land, costing over $9,000,000, were purchased, bordering on a harbour inlet. The most interesting feature is a loop-shaped subway over which the suburban trains will be worked electrically on the third rail system, without shunting. Seven hundred and ten trains use the station each day. Electric lifts are used. A novelty is the provision of distinct platforms for luggage, to avoid hampering the passenger platforms. The total cost of buildings and land was $14,000,000. E. H. C.-H.

927. *Lausanne Tramways.* **C. du Riche Preller.** (Engineering, 66. pp. 769–772, 1898.)—There is over 1,000 feet

difference in altitude between places on the 16-mile system, of which 8½ miles have already been built. Less than 50 per cent. of the line has a gradient of 0 to 3 per cent., while 21 per cent. has 5–7 per cent. grade, 3 per cent. has 7–9 per cent., and 2 per cent. has over 11 per cent. grade. Curves of 66 feet radius coincide with 8 per cent. grades. In many parts the roads are only 18 feet wide. Except 440 yards, which is paved, the system is laid in macadam on meter gauge with 4½ in., 60 lb. girder rails, laid on 6 feet iron sleepers, weighing 46 lb. each. The total weight of permanent way is 170 lb. per yard in macadam, and 200 lbs. per yard in paved roadway. On the 11·3 per cent. grade, wooden boards 4·4×4·8 in. are placed alongside and outside the rails for the safety brake. The rails are bonded with 8 mm. copper wire, keyed and soldered to the rails. The power station is central, and contains three sets of Crossley gas engines connected through Raffard friction couplings to Thury dynamos. Each set has two twin 75 H.P. gas motors, with 8 feet fly-wheels weighing 6½ tons each. The gas generating plant, by Fichet and Heurtey, of Paris, is a modified form of Dowson plant, in three sets corresponding to the three gas engines. The system employed admits of the use of poor and small-sized St. Etienne coal (1/5 in. to 4/5 in.) costing less than 28s. per ton delivered, in conjunction with Belgian anthracite of the same size. The cost of fuel works out at 0·5d. per car mile, corresponding to 1·3 lb. coal per H.P. hour. A Pollak battery of 700 ampere hour capacity works in parallel with the dynamos and the line. The rolling stock comprises 21 four-wheeled motor cars, carrying 14 passengers inside and 9 on each platform, and fitted with two 20-H.P. Thury motors with single-reduction pinion gearing 1:9. The motors always run in parallel, the regulating resistances being on the car roof: this gives smooth and instantaneous starting. On all down grades the motors are run as generators on the resistances. On the 11·3% grade there is a stopping-place requiring a starting current of 120 amperes at 500 volts at the generating station. A special safety brake is used consisting of two toothed steel blocks, which can be forced down on to the planks outside the rails with a force of one ton per block. This is effective for instantaneous danger-stops. Heating is effected by radiators of 2·5 kw. Current is taken from the trolley wire by a slide shoe with renewable contact of alloy. The cars average 50 miles per car per day, and receipts vary from £12 to £60 per day. The number of passengers carried is 50 per head of population per annum. Tables of staff, cost of construction, working expenses, and other interesting data are given. The costs of the power station and plant, comprising three 150 H.P. sets, and a storage battery equal to a further unit, work out as follows:—

For gas plant and gas motors, £13 per H.P.; for dynamos and accessories, £8·9 per H.P.; for accumulators, including a reserve battery, £17·2 per H.P.; for land, works, and buildings,

£15·8 per H.P. It is contemplated to eventually use the present station as a reserve, working the whole system from water-power at St. Maurice on the Rhone, where 9,000 to 14,000 H.P. are available. The transmission over the 40 miles to Lausanne is to be direct current at 22,500 volts in two cables of 150 sq. mm. section; 7 per cent. loss in transmission is estimated. The author notes that there is a continuous current transmission at 14,400 volts at Chaux de Fonds (Jura). E. H. C.-H.

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928. *Electric Traction at Washington.* (Elect. World, 32. pp. 707–715, 1898.)—An account is given of the construction of the conduit, and of the equipment of the new power station at Washington. The alterations necessary in the existing cable conduit are described. The power house contains eight boilers, each of 350 nominal H.P., which supply five 800 H.P. Allis-Corliss tandem-compound engines. The exhaust of each engine first passes through a Hartford feed water heater, and then to its own jet condenser. There is a very complete plant for the handling of coal and ashes. The switchboard is of standard General Electric construction. It includes throw-over switches so that the polarity of any section may be reversed; if earths occur on different sections they may by this means be all placed on the same side of the system, and a short circuit from this cause avoided. A single starting-rheostat is made to serve for any of the boosters by specially designed switches. There is a protective device for the booster generators, which acts in the event of the circuit breaker of the motor opening. A water rheostat is also included for the purpose of burning out earths. W. R. C.

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929. *Accumulator Sub-stations for Electric Tramways.* (Elect. World, 33. pp. 75–76, 1899.)—To cope with the rapid increase in the load on the generating plant of the Metropolitan Street Railway Company, New York, U.S.A., two storage battery sub-stations have been installed, each consisting of two batteries in parallel, and capable of giving 8,000 amperes for one hour. A booster is used to assist in charging and discharging the battery, but during a large part of the day the battery "floats" on the line; the number of cells in series is not varied at any time. The battery is to be kept on the mains in emergencies, whatever happens. The booster is provided with differential excitation by means of series and separate exciting coils, the latter being connected with two resistances joined across the mains in such a way that the exciting current can be varied in strength and in direction by turning a switch, without ever opening the circuit. The ordinary load of each sub-station is about 800 kilowatts.

A. H. A.

930. *Mixed System at Hanover.* (Street Rly. Rev. 8. pp. 801–802, 1898.)—This article is an abstract from a paper read by T. Krüger at the Geneva meeting of the Permanent International Tramway Union. Information is first given as to the treatment of the cells. The batteries weigh from 4,400 to 5,500 lb., and comprise 202 cells with a capacity of 25 ampere hours at a discharge rate of 25 amperes. After running 5,000 to 7,500 miles the batteries are cleaned; when this is again necessary, new plates are fitted. Negative plates are repasted, the grid lasting through six "repastings," or 150,000 miles. The cost of repasting is 76 marks (£3 16s.) per car. New positives cost 707 marks (£35 7s.) per car. The cost of maintenance and renewals from August 1, 1896, to August 1, 1898, amounted to 0·405d. per car mile. In order to obtain a long life of battery it should be chosen so that not more than one-half the capacity will be required. The average life of batteries in 37 cars was 23,417 miles; that of the positives in seven cars was 24,528 miles; and that of the negatives in two cars was 23,321 miles. Inspection and cleaning are essential. The power apparently costs ½d. per car mile when the batteries are in use, and ⅛d. per car mile when not in use, in excess of that which would be required with a simple trolley. W. R. C.

931. *Liverpool Electric Tramways.* (Railway World, 7. pp. 372–376, 1898.)—Large new double-bogie centre-vestibule cars are now in use. They carry forty passengers, and cost less than the ordinary motor and trial car, which do not together hold as many. They are fitted with Standard air brake equipment, the compressor being geared to the axle and automatically put into action only when the air-pressure falls. A constant pressure of 3½ atmospheres is maintained in the reservoir. The brake cylinder acts directly through a push-rod on to the equalising lever, through which the hand-brakes also operate. The connection, however, is not rigid, so that when the hand-brake is used the power mechanism remains at rest. On emergency the 13-ton cars at full speed can be stopped within their own length. (See also 1899, Abstract No. 517.)

E. H. C.-H.

932. *Electric Traction at Lyons.* (Electrician, 16. pp. 331–338, 1898.)—The whole of the above traction circuit has been divided into five independent sections, and each connected to a feeder in such a manner that if an accident occurred to one of these sections, the remainder of the circuit would not be affected. A portion of the circuit is worked on the overhead trolley system, and the remainder by means of the central underground conduit system. The "go" and "return" cables to the motors are insu-

lated from the rails and consequently from earth, and current is supplied to them by two feeders entirely insulated and completely insulated from the other feeders of the circuit. A map shows the disposition of the feeders, a special feeder being provided for the underground portion of the line.

The feeders consist of rubber-covered cable, protected by two iron armourings.

The positive feeders were calculated according to Kelvin's formula for maximum economy. This could not be applied to the negative feeders owing to the necessity of making the point of contact of these to the rails, equipotential. In order to control this drop, and regulate it from the station by means of auxiliary resistances, the ends of these cables were connected by means of pilot wires to special instruments, allowing the difference of potential between the ends of each of the feeders to be measured. The power house is one of the most important which have been built in France. The switchboard is provided with a water resistance which answers several purposes. It can be connected to one of the feeders, and thus reduce the pressure.

In this manner one can prevent too great a leakage of current in the event of the culvert becoming flooded. In the case of a short circuit on a feeder the resistance becomes of use in reducing the pressure to allow just enough current to pass to burn out the fault. This resistance is also used for sending a current through the rail bonds between the ends of two feeders for the purpose of testing the resistance of the bonds. L. J. S.

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933. *Jungfrau Electric Railway.* **C. King.** (Railway World, 7. pp. 358–362 and 397–400, 1898.)—The Jungfrau Electric Railway has already been referred to in Science Abstracts, No. 91 (1898). The present paper contains a description of the rack rail designed by M. Strub; the designer's aim being to produce a rack which should be easy to make, cheap in maintenance, and, above all, should as far as absolutely possible provide against all contingencies. The most serious and difficult point to be met is the possibility of the pinions mounting the rack. The rack consists of a single rolled rail 170 mm. height, with a high head, in which the gearing teeth are formed. The bottom of the tooth space is inclined from the centre line, so that any ice formed on the rack may be forced out by the pinion. The lower part of the head is tapered downwards, and is utilised for safety grips, which come into action if there should be any tendency for the pinion to mount the rack. The grips can also be operated by hand, so that they may form a very powerful and absolutely safe emergency brake. The rack weighs 34 kgms. per metre. It has a tensile strength of 29 tons per sq. in. and an elongation of 20 per cent. A description of the tunnelling operations now being carried on is given, and also a short description of the power plant. A. S.

934. *Experimental Electric Railway Line.* (Zeitschr. Elektrotechn. Wien, 16. pp. 589–591 and 605–608, 1898.)—The article contains an illustrated description of the arrangements about to be adopted by the Prussian Government in connection with electric traction experiments on a section of the Wannseebahn suburban railway in Berlin. A. H.

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935. *Electric Traction for Metropolitan Railways.* **P. Dawson.** (Soc. Arts. Journ. 47. pp. 399–407, 1899.) — Steam locomotives are unsatisfactory where stops are frequent; they cannot speed up rapidly, chiefly because the torque on the driving axles constantly varies with the reciprocation of the pistons; their fuel consumption is practically the same whether standing still or exerting full power. Electric energy may be transmitted to motors on the cars, through conductors laid along the track, by direct current, with or without accumulator substations and negative boosters to reduce the drop, or by polyphase currents, or by a combination of both. The three-wire system, using the rail as the neutral wire, has been tried and found wanting. Parshall supports the contention that for any power station of more than 4,000 kw. capacity, *i.e.*, for all suburban and metropolitan lines, the polyphase system is commercially the only admissible one. The chief aim is a high average speed, with a low maximum. The time between reaching maximum speed and applying brakes should be at least 4 to 6 times that required for stopping the train, so as to allow for errors of judgment. By suitable arrangement of gradients at stations, 40 to 50 per cent. of the total power required by a train may be saved. Potter's tests showed that during acceleration the average current required was 32 amps. per ton weight of train. On the Metropolitan Elevated, Chicago, a 4-car train with an average speed (exclusive of stops) of 12·2 miles per hr. required ·042 unit delivered at switchboard per ton-mile: at 14 m.p.hr. this figure rises above ·050. A table is given showing the changes in power consumption over a given distance (2,000 ft.) in a given time (75 secs.) when the times of application of power and brakes are varied. With power applied for 7·5 secs., the maximum speed was 25·75 m.p.hr., brakes were on for 10 secs. and the consumption was ·035 unit per ton. Respectively corresponding figures were 53·0 secs., 36·5 m.p.hr., 22 secs., and ·084 unit per ton. From actual results on the Chicago Elevated and the Metropolitan (London), 25 miles per hr. is attained in 10 secs. with electric traction, and in 33 secs. with steam locomotives. The consumption of coal on English main lines is 3 to 4 lb. per I. H. P., which is electrically equivalent to 13 lb. of coal per B.T.U., whereas a unit can actually be delivered at switchboard for a trifle over 3 lb. of coal. The three types of elevated railway equipment are (1) the steam locomotive, using 10 to 15 per cent. of train weight for

traction; (2) the electric locomotive, using 30 to 35 per cent.; and (3) the Sprague multiple-unit system, using anything up to 60 per cent. of the train weight. With the last system on the S. Side Elevated in Chicago, the transportation expenses for July, August, and September, 1898, were 1·9 cents per car mile, whereas for the same months in the previous year with steam locomotives they were 2·8 cents per car mile.

A few details are given of the two large power stations now being equipped for the Metropolitan and Third Avenue lines in New York. The former will contain 11 direct-coupled 3,500 kw. sets with Allis vertical engines, giving 6,600 volts at a frequency of 25 and a speed of 75 r.p.m. The fly-wheel rims will weigh 100 tons. Sub-stations will reduce the pressure to 350 volts, which will then pass through rotary converters to the line at 500 volts. As regards long-distance transmission, 4,000 H.P. is now regularly transmitted 85 miles to Sacramento, California, at 30,000 volts; 1,000 H.P. at Telluride, Utah, are sent 55 miles at 40,000 volts.

Discussion (pp. 408–412, 1899). **C. Carus-Wilson.** For the class of service dealt with in the paper, the efficiency curves of motors are of little importance, as the value of the efficiency at a certain speed does not go for much. The value of gradients at stations could be shown to be greatest when they act during the first few seconds, but this is practically impossible, and hence too much advantage should not be claimed for them. **L. Gaster** said trains had been working for some time in Switzerland with three-phase motors. **E. K. Scott** confirmed this, and believed three-phase motors would accelerate as quickly as continuous current. **J. Swinburne** remarked that a drawback to a polyphase motor was that it required three contacts instead of two, but he could not see why it should not give sufficient starting torque. To get large torque with direct current, the armature current and the field excitation are increased. This can equally well be done in a polyphase motor where, whatever the nomenclature, the two elements exist. One element is connected to the line and gets alternating currents, and the field or the induction can be increased by reducing the number of turns. The other element has an induced current in it which depends solely on the resistance in circuit to start with. With regard to steam locomotives, the acceleration difficulty is that one cannot do more than fill the cylinder with steam, and if the cylinder is large the expansion is too much when running rapidly. **W. M. Mordey** remarked that with direct currents, the small E.M.F. and large current required for starting are obtained by waste in resistances. With alternating currents a back E.M.F. can be inserted, which is not wasteful. E. H. C.-H.

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936. *Three-Phase Currents for Traction.* **E. K. Scott,** (Instit. Elect. Engin. Journ. 28. pp. 108–119, 1899.)—The

Zermatt-Gornergrat Railway was the first to be equipped with three-phase plant. It is 5½ miles long and works with a rack, the heaviest gradient being 20 per cent. There are two double trolleys of "lyre" pattern (two per phase), each being insulated in the middle, so as to take current from the two wires. The complete train, weighing about 28 tons, runs at 4½ m.p.hr., the total tractive effort being 6 tons. Each locomotive carries two 90 H.P. motors of the asynchronous three-phase induction type, with wound rotor and contact rings, permitting the introduction of ordinary low-voltage resistances for speed regulation. They start under full load with not more than the current required at normal speed, run at 800 revs. per min. with 40 periods per sec., weigh 2½ tons each, and actuate the rack wheel through double reduction, 12 to 1, gearing. In descending, when the motors reach speed of synchronism they act as generators, and cannot exceed that speed. If one wire be interrupted, the motors act as single-phase machines of reduced power. Current is generated at 5,400 volts and transformed down to 540 volts at three sub-stations by two groups of three 30 kw. single-phase transformers at each station. An important point in three-phase traction is that with the controller at the full speed notch the speed is, within limits, independent of load and gradient. The system has a large field on lines running long distances between stops. Appendices give short descriptions of the Lugano, Jungfrau, Evian-les-Bains, Engelberg, and Thun multiphase lines. E. H. C.-H.

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937. *Electric Traction.* **H. F. Parshall.** (Elect. Engin. 23. pp. 114–116, 1899. Paper read before the Northern Society of Electrical Engineers.)—Lighting plant usually works at full load only a few hours per day, whereas traction plant has many hours of it, justifying greater capital expenditure in coal-handling machinery, steam piping, mains, &c. A heavy fly-wheel is the most economical method of getting the maximum effort from the steam engine for taking overloads. Good governing costs no more and certainly does no harm. In large units the mechanical and electrical requirements as to speed generally coincide. The distance at which continuous currents become more efficient than multiphase currents varies with the ratio of the average to the maximum temporary load. Rotary converters at constant speed give constant volts regardless of load, and can therefore satisfactorily supply both traction and lighting installations. Where there are rotary converters feeding into a network at constant voltage care must be taken to select engines with constant angular velocity and mains with small drop, equal in each phase. The greatest difficulty in large multiphase stations is the switching apparatus, particularly the circuit breakers. The limit for a 500-volt continuous current station is reached at 5,000 kw. output. Beyond this, multiphase transmission with rotary transformers and continuous current distribution becomes necessary.

E. H. C.-H.

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938. *Power Distribution for Electric Traction.* **E. Wilson.** (Engineer, 87. pp. 51–52, 1899.)—In this paper the author compares the systems in use, and discusses the subject in general terms. Alternate-current and direct-current generators, overhead and underground conductors, two- and three-wire systems for traction, high tension transmission, and storage cells are discussed in turn. A. S.

939. *Successful Running of Suburban Railways.* (Street Rly. Journ. 14. pp. 755–763, 1898.)—This article deals with the influence of competing tramways upon the successful financial running of suburban railways which only stop at fixed stations. The New York and Brooklyn railroads have lost heavily during the last two or three years owing to the competition of fast trolley street cars. The only way to counteract this competition is to adopt high acceleration on the railroads. The accelerations are compared of the steam locomotive, of the electric locomotive, and of the "multiple unit" (Sprague) system. Speed curves are given of each of these. Tables are also given of acceleration and braking data of several railways, due to W. B. Potter. Maintenance and general expenses are discussed. In 1897 the operating expenses of the Manhattan Company, working with steam, were 12·3 cents per mile (43,181,582 car miles). If the same service had been run electrically, it is estimated that the expenses would have been 10·9 cents, and if 50,000,000 car miles had been run with increased acceleration the expenses would have been 9·55 cents. A higher dividend would have been earned even if the electrical equipment had cost $10,000,000. W. R. C.

940. *Mechanical Traction.* **E. A. Ziffer.** (Street Rly. Journ. 14. pp. 710–713, 1898.)—Steam motors have been much improved, but the location of the boiler next to the passengers is objectionable. Of stored steam motors, the Dodge promises success. Compressed air systems have made little progress in Europe, but are to be tried on a large scale in America. Gas locomotives are an advance on gas motor-cars, but the smell still penetrates. Gasolene motors are not so good as benzene motors, which are being tried on the Wurtemburg State Railways. Traction by accumulators and by surface-contacts is still experimental. The third-rail system is the cheapest to install of any, and gives good results on private roads. E. H. C.-H.

941. *Electrolysis in Ground Returns.* **A. B. Herrick.** (Street Rly. Journ. 14. pp. 775–779, 1898.)—When current leaves a metallic surface buried in the earth, it does not carry

with it the decomposed metals and deposit them on the kathode as in a plating bath. Instead of this, they lie adjacent to the surface acted upon, usually in the form of oxides, which increase the resistance of the leakage path. Water accumulates at the negative plate and is repelled from the positive: this action increases with the current density. The voltage at which electrolysis begins varies from 1·5 for pure water to 0·37 for a 10 per cent. sodium chloride solution. When a station is shut down there is often 0·5 volt due to the battery action of the buried iron. Practical methods are given for measuring current in a water-pipe, between the soil and the pipes, &c. E. H. C.-H.

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942. *Thompson-Walker Surface Contact System.* **M. Walker.** (Instit. Elect. Engin. Journ. 28. pp. 239–272, 1899.)—A surface contact system cannot be satisfactory unless (1) the contacts in the roadway do not form obstructions to traffic, (2) the method of picking up current from studs by means of a skate is feasible under practical working conditions, and unless (3) the studs can be made perfectly safe. Hollows $\frac{3}{4}$ in. deep are common in roads; the studs in Thompson's system are only $\frac{3}{4}$ in. above the road surface. A stud is easier to insulate or renew than a rail. The skate is made of U-steel girder $4\frac{1}{8}'' \times 2\frac{1}{2}'' \times 18$ feet long, bent up at the ends and so carried on springs as to allow a tilting of the ends. The switches take $\frac{1}{10}$ second to close, and studs can therefore be $14\frac{1}{2}$ feet apart for an 18-feet skate. Tests show that the average leakage in wet weather will be $\frac{1}{2}$ ampere per car, rising to 5 amperes in a bad road. The switch is based on the principle that a magnet cannot attract air. The iron plunger, which works the actual contact-yoke with a hammer blow, is magnetised by a solenoid, but will only rise when the skate comes over it. The plunger is a loose fit in a cylinder and cannot stick. If the yoke did stick up the plunger is arranged to make an earth and blow the fuse. The studs are faced with hard phosphor-bronze, and form the lids of the switch boxes. Any one can be removed, with its attached switch, in two minutes. A 500-volt accumulator battery is carried for making the first stud alive. (See also Abstract No. 217, 1899).

E. H. C.-H.

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943. ***Stendebach and Linker's Combined Conduit and Surface-Contact System.*** (Elect. Rev. 44. pp. 151–154, 1899.)—The conduit admits a merely mechanical plough on the car, which works a rack in the adjacent switch-box, thereby rotating an insulated disc carrying contact pieces, which connect the feeder to the stud in the road above. E. H. C.-H.

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944. *Conduit Construction in New York.* (Street Rly. Journ. 14. pp. 791–794, 1898.)—The Third Avenue Railroad Co. is about to change over its 60 miles of line from horse and cable to conduit. The new 107-lb. girder rails in 60 feet lengths will be carried on wooden stringers 5½ in. wide × 6 in. high, laid in 30 feet lengths: this will give an easy riding track. The third rail, of 21-lb. T-steel, and its insulators are similar to those used by the Metropolitan Street Railway Company. In parts, the old cable conduit will be adapted; the rails will be carried from the yokes on spring liners. Thirty-two feet convertible cars will be used with "G.E. 52" motors and Brill "27 G" bogie trucks: total weight of car, 36,000 lb. Provision is made for attaching a special trolley pole for manipulation in the car-sheds.

E. H. C.-H.

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945. *Thomson's System of Electric Train Control.* (Elect. Engin. N.Y. 27. pp. 95–96, 1899.)—To have each car of a train independent is conducive to economy. E. Thomson provides a master-controller in positive synchronous relation with the individual motor controllers. A diagram of connections is given.

E. H. C.-H.

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946. *Track Construction.* **D. F. Carver.** (Elect. Rev. N.Y. 33. p. 187, 1898.)—Good foundation is essential for good construction. If not naturally good, broken stone or gravel will make it so. Ties should be of best yellow pine, sawed four sides, and having a bearing of 4½ square feet per tie; 24 ties per 60 feet rail is found best. Ties under joints should be tamped throughout their length; others at their ends. It is now common to bevel rails on the tread to give the wheels a bearing over the whole width. The lightest section of 9-in. rail is more than amply strong, hence it is found desirable to roll the web down to thinnest possible and accept the loss (about 0·25 per cent. of rails laid) due to rails splitting along the web owing to unequal tension. A satisfactory solution of the rail-joint problem is fast being found in either welded or mechanical joints. The latter makes use of the base of the bearing surface under the head and of the surfaces of the rail. With girder rail in block-paved streets, a rail filler must be used; burnt brick crumbles under heavy traffic, and has been replaced by hemlock planks, which give the best results on the investment. The author has found that the interest on concrete between ties to prevent pavement from sinking is often in excess of the maintenance charges which it is intended to prevent.

E. H. C.-H.

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947. *Applications of Accumulators.* **J. Appleton.** (Elect. Engin. N.Y. 27. pp. 150–151, 170–172, and 201–202, 1899. Paper read before the New York Electrical Society.)—After referring to the present position of accumulators from the commercial point of view, the author discusses their advantages and their application on a large scale. The Chicago Edison Company has installed with good results a battery capable of discharging at the rate of 11,000 amperes for 1¼ hours. As to whether batteries should be used at the main power house or at sub-stations depends upon the conditions of each particular case. Where power is charged for at so much per H.P. per annum, the power being available twenty-four hours per day, it is worth a customer's while to put in a battery, and to rent a smaller H.P. In connection with traction systems, a battery may be installed at the power house, or at the end of a long feeder. The Buffalo Street Railway Company has erected a battery at the power house which is charged by power from Niagara, and enables the Company to shut down for twelve hours a day. The power rented from Niagara is also much less than was the case before the battery was in use. As an instance of the use of batteries at the end of feeders, the system of the South Side Elevated Company of Chicago may be mentioned. Other installations are also described.

W. R. C.

948. *Central Station Design.* **B. J. Arnold.** (Elect. World 33. pp. 172–174, 1899. Paper read before the North-western Electrical Association).—The author refers to the present trend of engineering practice, first as to boilers, engines, generators, economisers, mechanical draught, condenser plant, motor-driven auxiliaries, multi-circuit dynamos, &c., and then to the central station as a whole. W. R. C.

949. *Charging for Electrical Energy.* **G. Pellissier.** (Soc. Int. Elect. Bull. 15. pp. 395–415, 1898.)—The author describes and discusses in detail the various systems of charging in use, and concludes that the Wright system most nearly approaches the ideal indicated by theory. In his opinion it would be better to double the fixed price, and to make the reduced price applicable after the first half-hour of use, instead of the first hour as at present, in order to place the whole of the consumers on the same basis. A. H. A.

950. *Charging for Electrical Energy.* **W. Arnot.** (Elect. Engin. 22. pp. 716–719, 1898.)—In this paper, read before the Institution of Engineers and Shipbuilders in Scotland, the author discusses electricity meters and methods of charging for electrical energy. By quotations from provisional orders it is shown that

all meters should be examined and certified by inspectors appointed by the Board of Trade. Load curves are given for Edinburgh and Glasgow, and the working costs compared in detail. The Wright system of demand indicators is explained, and compared with other systems, and the question of charging for motive power is briefly dealt with. A. H. A.

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951. *The Photometry of the Enclosed Alternating Arc.* **C. P. Mathews, W. H. Thompson,** and **J. E. Hilbish.** (Amer. Instit. Elect. Engin. 15. pp. 599–617, 1898.)—Photometric measurements with enclosed arcs are less subject to colour difficulties than open arcs, since the enclosing opalescent globe absorbs rays of short wave-length in greatest proportion and brings the colour of the arc nearer that of the standard. An obstacle to careful measurement is the variation of the intensity of alternating arcs due to the wandering condition of the arc. To enable instantaneous photometric readings to be taken use is made of a device due to Matthews, by which settings can be recorded and read after a series of observations have been taken. (See 1899, Abstract No. 542.)

The standard source is a glow lamp, being referred after each test to the Hefner lamp.

The following is a summary of the results of the test of one lamp:—

Volts	103·2
Amperes	5·84
Apparent watts	602·0
True watts	407·0
Watts in mechanism	80·0
Power factor	0·67
Maximum intensity	203·0
Direction of maximum intensity below	50°
Ditto above	30°
Mean hemispherical intensity—	
Upper hemisphere	91·8
Lower hemisphere	129·1
Mean spherical intensity	110·5
Watts per mean spherical, Hefner unit	3·68
Watts in arc per mean „	2·96
Watts in arc	327·0
Character of globes	opalescent inner.
Carbons	½-inch "Electra."

The power factor is due to the inductance in the mechanism.

This is compared with a direct-current enclosed arc, and the authors infer that as regards efficiency, or watts per Hefner unit, the direct-current arc is superior to the alternating-current one.

W. G. R.

952. *Arc Light Formulæ.* **W. Harkness.** (Amer. Assoc. Proc. 47. pp. 140–142, 1898.)—The variable elements in an arc lamp are: 1st, the energy resulting from the drop of potential between the carbons; 2nd, the diameter of the carbons; 3rd, the length of the arc; and, 4th, the quality of the carbons.

If M is the maximum intensity of the light emitted when the power consumed is W watts, and the diameter of the carbon is d millimetres, then, according to Max Schreihage,

$$M=\frac{n\,W^{\frac{3}{2}}}{d}$$

where n is a constant determined by experiment.

The author gives an empirical formula deduced from tests on thirteen arc lamps at the Paris Exhibition of 1881, in the form—

$$M=0{\cdot}0575\,(1 \pm 0{\cdot}068)\,\frac{W^{1\cdot6}}{d}\ \text{carcels,}$$

and another from tests on twenty-five lamps at the Antwerp Exhibition of 1885, in the form

$$M=0{\cdot}0759\,(1 \pm 0{\cdot}0208)\,\frac{W^{1\cdot6}}{d}\ \text{carcels.}$$

Other tests by L. B. Marks in 1890, on seven lamps, give

$$M=0{\cdot}0802\,(1 \pm 0{\cdot}0888)\,\frac{W^{1\cdot6}}{d}\ \text{carcels.}$$

The diameter of the carbons is given by

$$d=m\,\sqrt[3]{W}$$

where—

$$d=1{\cdot}52 \pm 0{\cdot}16.$$

Also if H is the horizontal intensity and S the mean spherical intensity, the formula

$$S=\tfrac{1}{2}\,H+\tfrac{1}{4}\,M$$

is deduced empirically, and putting

$$\frac{M}{H}=n$$

tests on fifty-six lamps give

$$n=\frac{M}{H}=2{\cdot}416$$

W. G. R.

953. *Most Economical Life of Incandescent Lamps.* **B. L. Montel.** (Zeitschr. Elektrotechn. Wien, 16. pp. 594–596, 1898.) —The author explains a graphical method of determining the number of hours during which an incandescent lamp should be kept in circuit in order to comply with the condition of lowest cost per candle-hour. A. H.

954. *Bergmann Arc Lamp.* **P. Letheule.** (Électricien, 16. p. 400, 1898.)—In this lamp the only regulating mechanism consists of a series solenoid and an iron core. The core forms the carbon-holder and is made heavy so that the weight of the carbon is negligible relatively thereto. The solenoid has its interior made so as to fit close to the core in the middle of its length but tapers away towards its ends, so as to render the magnetic attraction uniform throughout the travel of the core. The upper end of the solenoid is closed, so as to form an air dash-pot for the core. The current passes to the upper carbon through the core and the metal tube on which the solenoid is wound. C. K. F.

955. *Sonia Enclosed Arc Lamp.* (Elektrotechn. Ztschr. 19. p. 660, 1898; also Écl. Électr. 17. pp. 488–490, 1898).—This is a ring-clutch lamp, in which there are various improvements in details. Drawings are given in the original paper. C. K. F.

956. *Arc Lamps.* **R. A. Ross.** (Canad. Elect. News, 8. pp. 222–223, 1898.)—In this article the author deals with the comparative advantages of the various systems of arc lighting, and gives the following table (in which "Outside" indicates outdoor lighting, and "Inside" indicates the lighting of interiors):—

LIGHT-GIVING EFFICIENCIES OF DIFFERENT ARC LIGHT SYSTEMS.

		Volts in		Watts in		Candle Power.		Watts per C.P.		C.P. per H.P.	
	Amperes.	Arc.	Line.	Arc.	Line.	Outside.	Inside.	Outside.	Inside.	Outside.	Inside.
Direct Current.											
Series Open	10	45	50	450	500	650	450	0·7	1·0	750	520
Series Enclosed	6·5	70	75	450	500	375	450	1·2	1·0	440	520
Constant Potential Open	10	45	55	450	550	650	450	0·7	1·0	750	520
Constant Potential Enclosed	5·6	80	104	450	580	375	450	1·2	1·0	440	520
Alternating Current.											
Series Open	15	30	33	450	500	375	300	1·2	1·5	470	370
Series Enclosed	6·5	70	75	450	500	225	300	2·0	1·5	285	370
Constant Potential Open	15	30	33	450	500	375	300	1·2	1·5	470	370
Constant Potential Enclosed	6·5	70	75	450	500	225	300	2·0	1·5	285	370

C. K. F.

957. *Submarine Arc Lamp.* (Elect. Rev. N.Y. 33. pp. 241–242, 1898.)—This article is accompanied by two photographs of an arc lamp designed by Messrs. F. G. Hall, jun., and I. E. Burdick, for use in diving and wrecking operations. The description is somewhat meagre from a technical point of view.
C. K. F.

958. *Arc Lamps.* **G. Richard.** (Écl. Électr. 17. pp. 148–154, 1898; and 18. pp. 174–182, 1899.)—An illustrated description of a number of arc lamps. EDITOR.

959. *Nernst Electric Lamp.* **J. Swinburne.** (Soc. Arts Journ. 47. pp. 253–260, 1899.)—The light is obtained by rendering incandescent by means of an electric current highly refractory oxides worked up into little white rods. Each rod is mounted on two platinum wires by means of a paste made of refractory oxides. Such rods are, when cold, good insulators, but become conductors when heated. Since the rods fall in resistance as the temperature increases, an increase of current produces a decrease of resistance. This tends to give instability in running in parallel on supply circuits. This instability is corrected by a series resistance made up of fine wire and amounting to 10 or 12 per cent. of the whole resistance of the lamp. The consumption, including resistance, is 1·5 watts per candle for large lamps, and 1·6 for small lights. The lamp will not light up of itself, since the rod is an insulator when cold, but may be started by warming with a match or spirit lamp. The small lamps and the lamps of medium size are in practice started by a heating resistance. This is arranged close to the rod and in shunt to it. As soon as the rod is hot enough to conduct, its current works a tiny cut-out in the resistance circuit. In large lamps the heating system is a little more elaborate, as the resistance arrangement is arranged as a sort of hood which covers the rod. As soon as the rod conducts, not only is the resistance circuit broken, but the electromagnet lifts the little hood clear off the rod. In all these forms the rod and its mounting are replaceable without interfering with the rest of the lamp. The Nernst lamp is cheaper as to maintenance than either glow lamps or arc lamps, and cheaper than the latter in first cost. W. G. R.

TELEGRAPHY AND TELEPHONY.

960. *Space Telegraphy and Syntony.* **O. Lodge.** (Instit. Elect. Engin. Journ. 27. pp. 799–852, 1898.)—The author points out that slow magnetic pulsations being unaccompanied by an alternating electrostatic field do not emit energy, and do not therefore require a detector of radiant energy, a coherer; but the changes of magnetic conditions over a large area may be integrated by a telephone and circuit. The distance between two signalling coils is proportional to the two-thirds power of the diameter of the coils. Hence, coils of twice the circumference will signal to more than twice the distance with a given primary current. An emitting and receiving circuit each contains a condenser in series, and are tuned to respond to each other. The condenser is kept small by using frequencies of 384 per sec. The author proves that a simple induction method unaided by syntony is extravagant either in copper or power. With syntony, high frequency is an advantage, and the impedance is simply the resistance. An expression for the induced current in each case is given. The relative effects of conduction and induction at Lavernock are discussed. The self-induction capacity and frequency in several experiments (signalling up to 2 miles) are discussed, as also are the conditions and theory of tuning, the calculation of the best size and shape of coil for violent resonance and for maximum magnetic moment. A tuning-fork telephone receiver adapted to reproduce a special note, and a suspended coil receiver for working a transmitter to magnify sounds are described. Repeated magnification, a combined tuning-fork magnifying system, and a call are explained. M. O'G.

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961. *Space Telegraphy (Inductive).* **S. Evershed.** (Instit. Elect. Engin. Journ. 27. pp. 852–869, 1898.)—The author gives fundamental formulæ for the induction in secondary coil when telegraphing by horizontal rectangular coils. To get the greatest mechanical energy in the secondary the impressed E.M.F. must be in step with the current and the condition for maximum activity of a motor must be fulfilled, viz., the back E.M.F. must equal half the impressed E.M.F. The readable current in a Gower-Bell receiver was found by measurement to have a maximum (crest of wave) value of $2{\cdot}9 \times 10^{-6}$ amperes. The most audible frequency is 400, but the author anticipates that at this speed absorption by the earth will rapidly damp out the waves.

An ingenious relay receiver is described. It consists of a rectangle of wire having one end free to vibrate in a permanent magnet field. A current of the proper frequency will swing the rectangle into contact either with a stop or another similar rectangle vibrating. The amplitude is proportional to the impressed E.M.F. When E.M.F. and current are in the same phase, the power available in the secondary working a telephone at 400 ∿ is 600 times greater than that available in the rectangle relay at 16 ∿. M. O'G.

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962 *Magnetic Space Telegraphy.* **W. H. Preece.** (Instit. Elect. Engin. Journ. 27. pp. 869–967, 1898.)—In 1886 the author found that on earthing the ends of two (horizontal) speaking coils 4·5 miles apart, the results were the same whether the earth or metallic returns were used. Heaviside communicated between the earth's surface and a colliery 350 feet deep, but 400 feet of water was found to obstruct telephonic signals. The empirical formula

$$x=1{\cdot}9016\sqrt{\frac{C_1 l}{r_2}}$$

determines the distance x which should separate wires of length l, C_1 being the primary current and r_2 the resistance of the secondary. This established the fact that it was advisable to use copper conductors of the largest gauge that could be obtained.

An attempt to communicate from England to Ireland on the circuits from Carlisle to Haverfordwest, and from Belfast to Wexford, was spoiled by overpowering sounds of uncertain origin.

An appendix is added, explaining diagramatically the effects of adjacent rectangular coils. M. O'G.

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963. *Wireless Telegraphy and Electromagnetic Waves.* **Della Riccia.** (Bull. Ass. Ing. El. Liège, 9. pp. 161–230, 1898.)—This is a continuation of the author's former paper (see 1898, Abstract No. 1420), in which Marconi's experiments and results are described. J. L. H.

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964. *Wireless Telegraphy.* **A. Turpain.** (Comptes Rendus, 127. pp. 1208–1210, 1898.)—This paper considers the simultaneous transmission of signals along one wire to different stations by using Herzian waves of different wave-lengths and having resonators at the different stations, each one tuned to receive only the waves of one wave-length.

The principle of interference is used to stop or start the transmission ot waves of any particular wave-length along the wire from the particular resonator at the transmitting station. The two wires from the terminals of the resonator are joined together and then to the line wire; but between the resonator and the line wire a side branch, equal in length to one-half the wave-length, is inserted in one of the terminal wires. According as this branch is short-circuited or not, the resonator at the far station receives the signals or is silent. (This may be *vice versâ*, depending on the system of resonators.)

An experimental installation with a line 170 m. long, having three stations on it, was erected, and by the aid of five resonators simultaneous and independent communication was obtained between every two stations. J. B. H.

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965. *Wireless Telegraphy.* **A. Broca.** (Revue Scientif. 11. pp. 193–199, 1899.)—The author deduces from Poynting's conclusions that the heating of a conductor conveying a current is due to electrical energy coming to that conductor across its surface. Maxwell and Hertz showed that electrical waves move at the same speed along wires as across the air. Marconi's vertical wire when connected to Righi's spark knobs is compared to a pendulum of slow period whose point of support is a rapidly vibrating tuning-fork. The entire system will have a slight motion determined by the pendulum, but nearly all the energy will be absorbed in vibrating the bob. These vibrations propagate themselves along the wire. The flux of energy will also be along the wire, and when this flux arrives at the end of the wire its direction is determined in a plane at right angles to the wire, because the electrical force is normal to the surface at the end. The result is a plane wave corresponding to polarised light.

The history of coherers is summarised, and it is pointed out that when the metal powders are immersed in copal varnish there are given out minute globules of gas, which render the coherer insensitive, but which are reabsorbed as time goes on. Marconi's method is then described. M. O'G.

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966. *Pacific Cable.* **C. Bright.** (Mech. Eng. 2. pp. 632–634 1898.)—The maximum depth does not exceed 3,400 fathoms. Cables of which the density is reduced by covering each sheath wire with hemp lack durability; the wires (of 90 tons breaking strain) should butt against each other and be covered with thin cotton tape. Aluminium bronze tape ¼″ wide (composition not given) is recommended. Existing lines from Australia are summarised and the price per word by the Pacific scheme whether through Canada or United States would be reduced from 6s. to 2s. 6d. M. O'G.

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967. *Higgins' Printing Telegraph Apparatus.* (Electrician, 42. pp. 223–225, 1898.)—A description with detailed drawings is given of the Higgins' type-printing telegraph apparatus. The operator presses down one of thirty-six keys of the transmitter, according to the letter or figure he wishes to signal. This stops a pawl, interrupts the line circuit, and leaves the synchronised

type-wheel of the receiver motionless, with the letter signalled undermost. It also causes the printing-armature to fall back, releases a train of wheels which actuate a sprocket-wheel, and forces the "slip" against the type, thus printing the letter. As the sprock-wheel continues to move the "slip" is automatically drawn away from the type and fed forward. On depressing a key for a subsequent signal, the first key rises, the pawl re-engages with the revolving toothed wheel, the circuit is again completed, the current causes the type-wheel to rotate, the printing armature is at the same time held up until the current is again interrupted by the transmitter pawl, and the cycle is complete. The apparatus is worked by a magneto-machine, operated by a treadle. The speed of signalling is from 25 to 30 words per minute. R. A.

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968. *Multiple Switchboard.* **Dubreuil.** (Électricien, 16. pp. 299–302 and 317–322, 1898.)—A 9,000 subscribers' board is described in general terms. Details of an operator's set are described in the second article. Reasons are given for not having a single central exchange of very large dimensions. M. O'G.

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969. *Switchboard for Toll Lines.* **H. P. Clausen.** (West. Electn. 23. p. 50, 1898.)—Gives diagrams of 4 toll line connec tions and of the operator's instrument for 10 subscribers. M. O'G.

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970. *Straight "Express" Sectional Switchboard.* (Elect. Rev. N.Y., 33. p. 315, 1898.)—Double circuit cords with ringing and listening circuits normally cut out on both sides are illustrated. Sections of 5 drops are made complete in themselves, no wire being visible at front or back. Any coil is removed by rotating it a quarter turn and withdrawing it from the grip. M. O'G.

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971. *"Express" Telephone System.* **K. B. Miller.** (Amer. Electn. 10. pp. 288–291, 1898.)—Details are given, and a criticism of the necessity for the "B" operators telling the "A" operators which trunk to use. Phonographs are connected in to repeat "Busy; please call again" or "Subscriber does not reply." M. O'G.

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972. *Centralised Sources of Energy in Telephone Exchanges.* **K. B. Miller.** (Elect. World, 32. pp. 679–681, 1898.)—The systems of G. Anders 1881, I. Stone 1882 and 1893, C. Bell 1886, Anthony White 1890, and J. Carty, are described with diagrams. M. O'G.

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973. *London-Birmingham 76/.096 Telephone Cables.* (Elect. Rev. 44. pp. 128–131, 1899.)—The conductors weigh 160 lb. per mile and measure 96 mils. diameter, the resistance per mile at 60° F. is 5·852 standard ohms. The pairs are made up with a lay of 12 in. The arrangement is: Centre, 1 pair; first layer, 6 pairs; second layer, 12 pairs; third layer, 19 pairs. The lead tube is 160 mils. thick and 2·625 diameter. The capacity per mile of each wire with all others to earth is 0·1 mfd. at 50° F. The wire-to-wire of a pair capacity is 0·065 mfd. p.m. The cable is drawn into 3 in. pipes in 150 yard lengths. Illustrations are given of jointing and of the test pillars where dry air may be pumped in.
M. O'G.

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974. *Railway Telephone.* **L. Montillot.** (Électricien, 16. pp. 1–4 and 20–24, 1898.)—A line connects six stations in series. The line is duplicated and earthed at both its extreme ends: by using two lines and the earth, any station can select any other, and any two points by speaking do not prevent any other two from communicating on either side of the first couple. M. O'G.

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975. *Transmitter in Vacuo.* (Elect. Rev. 44. p. 265, 1899.) Kilduchevesky encloses a microphone in a sealed glass chamber, either vacuous or with an inert gas. The currents used may be large without oxidation, and packing does not occur.
M. O'G.

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976. *Eight Subscribers on One Pair of Wires.* **H. Webb.** (Amer. Electn. 11. pp. 30–32, 1899.)—Describes how, by using the earth and polarised relays, the exchange can selectively call up any one of eight without disturbing the other subscribers, and without clock-work. M. O'G.